AERONAUTICAL ENGINEERING REVIEW

MARCH 1949

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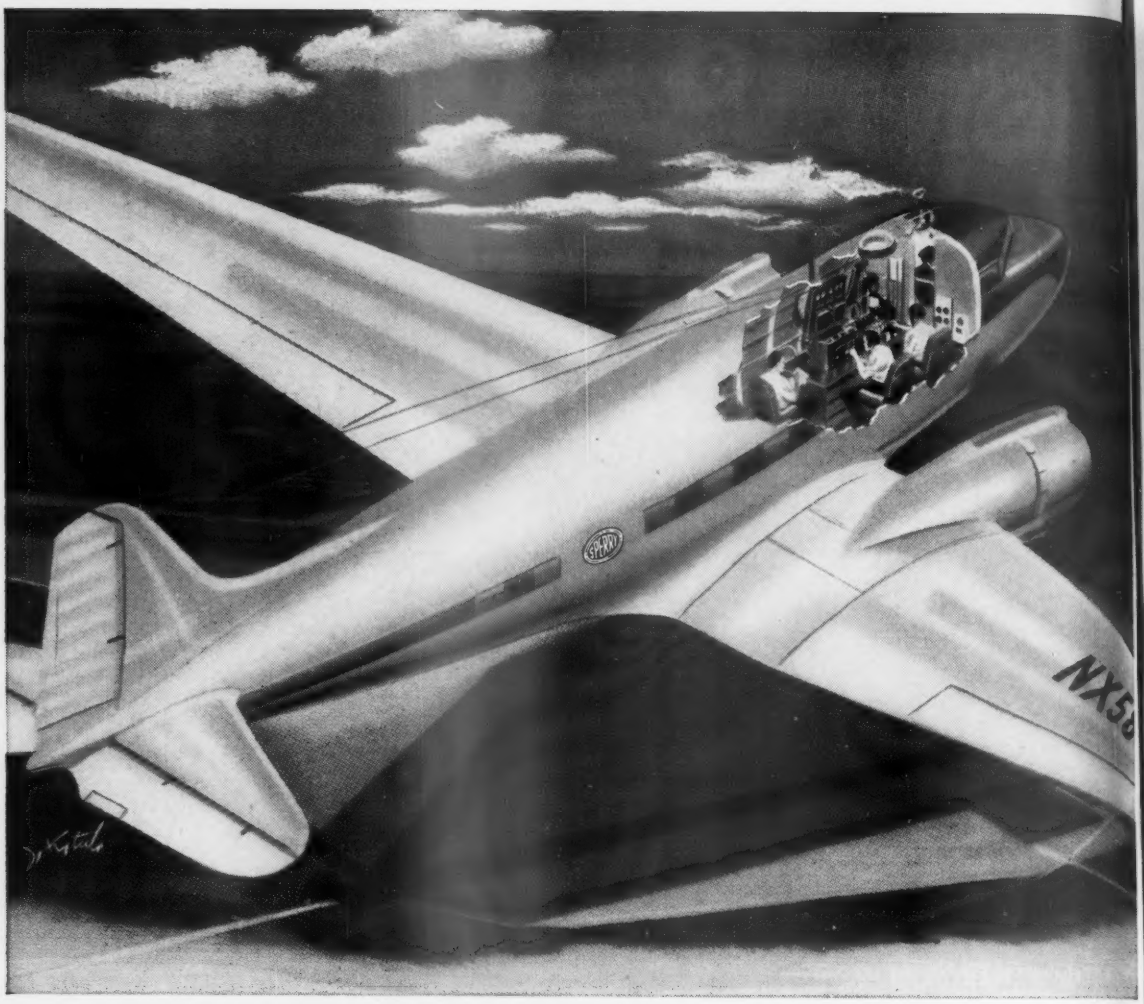

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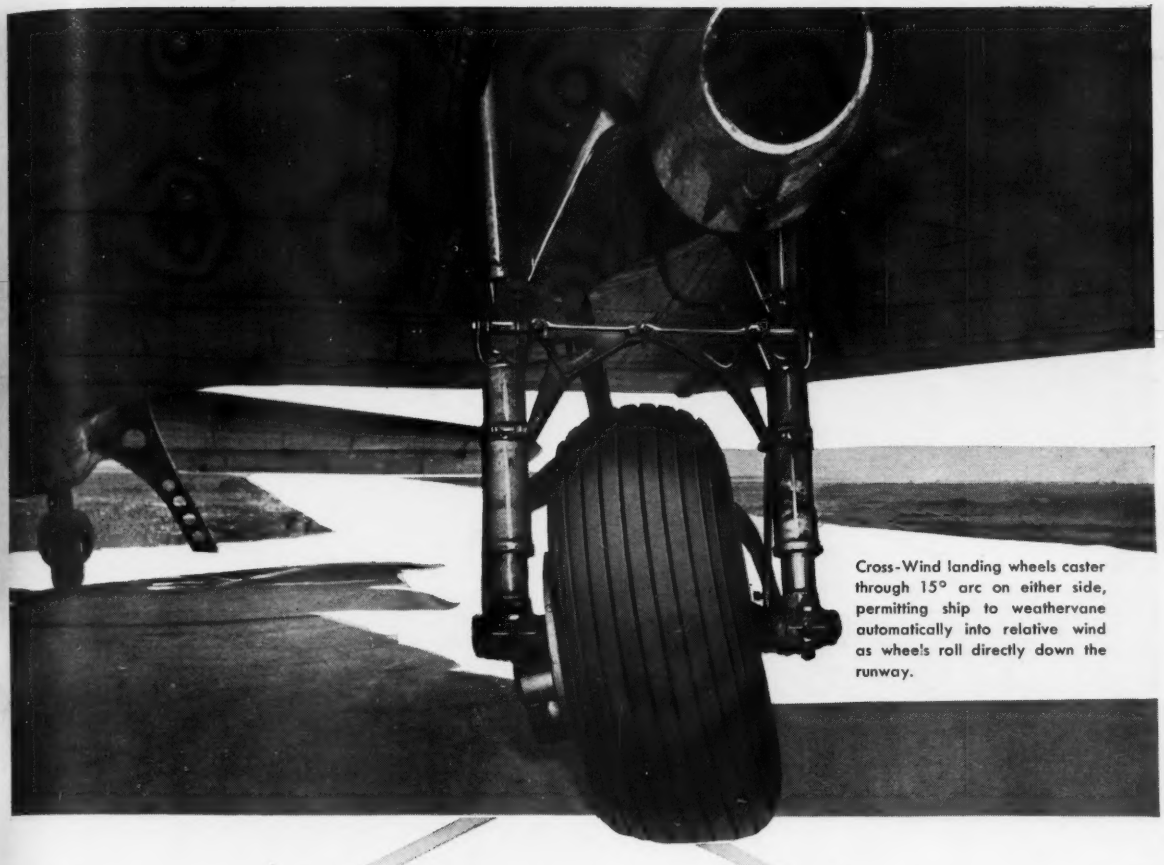

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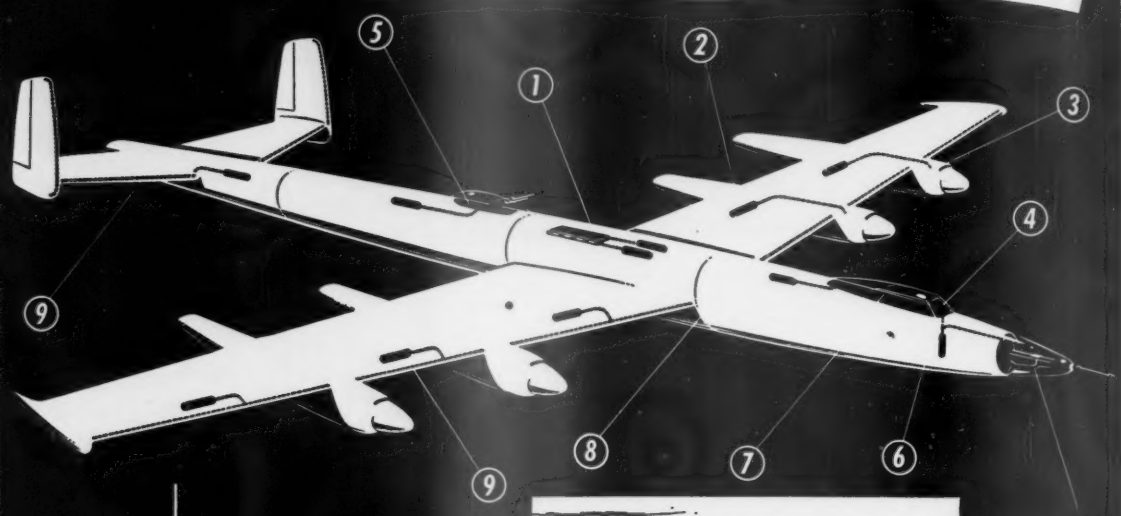

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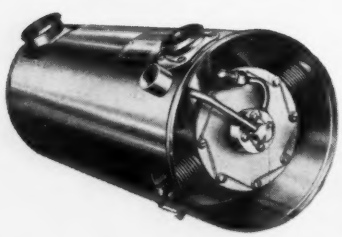

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AERONAUTICAL ENGINEERING REVIEW

Vol. 8 — MARCH, 1949 — No. 3

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Published Monthly by the Institute of the Aeronautical Sciences, Inc.

This is an actual photograph of the flow pattern of air moving at twice the speed of sound.

TWICE THE SPEED OF SOUND

▸ A small-scale model of a ram jet inlet is mounted in Wright's supersonic wind tunnel. As the air flows at mach No. 2 (twice the speed of sound) through the tunnel, *schlieren* apparatus—an optical instrument—accurately photographs the influence of the jet's body lines upon the flow pattern of the air. The oblique lines in picture represent shock waves created by impact of body on air.

▸ These *schlieren* pictures provide valuable new data on the phenomenon of compressibility—a condition that exists at the speeds attained by jet and rocket propelled aircraft and guided missiles.

▸ From them, Wright design engineers can determine the most efficient passage shapes for ram jets and other types of supersonic power plants.

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I.A.S. News

A Record of People and Events of Interest to Institute Members

Annual Business Meeting of the Institute

Reports of President, Treasurer, and Director

THE SEVENTEENTH ANNUAL MEETING of the members of the Institute was held at the Hotel Astor, New York, January 26, 1949. W. A. M. Burden, President of the Institute, presided.

Elmer A. Sperry, Jr., Teller, reported that he had received and counted 961 valid proxies for voting at the Annual Meeting—a quorum of the voting membership. Charles H. Colvin, Chairman of the Nominating Committee, placed in nomination the following members for election to vacancies on the Council: W. A. M. Burden, John K. Northrop, J. L. Atwood, C. J. McCarthy, G. S. Schairer, Elmer A. Sperry, Jr., and Earl D. Osborn, for a term of 1 year each; Preston R. Bassett, Luis de Florez, Sherman M. Fairchild, J. S. McDonnell, and R. G. Robinson, for a term of 3 years each; and the following area councilors for a term of 1 year each: Eastern Area—D. R. Shoults and H. Russell Young; Central Area—Willson H. Hunter and George H. Tweney; Western Area—R. G. Folsom and Willis M. Hawkins. On motion duly made, seconded, and carried, they were unanimously elected. The following were nominated and elected in like manner to serve on the Nominating Committee for 1949: Preston R. Bassett, Chairman, Charles H. Colvin, Smith J. De France, Hall L. Hibbard, J. C. Hunsaker, Clark B. Millikan, John K. Northrop, and T. P. Wright.

The Annual Reports of the President, Treasurer, and Director were read and approved. (See the following pages for the complete reports.)

The Secretary presented a list of honors conferred by the Institute in 1948 as follows:

The Sylvanus Albert Reed Award to George W. Brady, Chief Engineer, Propeller Division, Curtiss-Wright Corporation; The Thurman H. Bane Award to Col. James M. Gillespie, U.S.A.F. (ret.); The Robert M. Losey Award to Paul Armstrong Humphrey, Meteorologist, U.S. Weather Bureau; The John Jeffries Award to W. Randolph Lovelace, II, M.D., Head of Section on Surgery, Lovelace Clinic; The Octave Chanute Award to Herbert H. Hoover, Head, Langley Flight Research Operations, N.A.C.A.; The Lawrence Sperry Award to Allen E. Puckett, Chief, Wind Tunnel Section, Jet Propulsion Laboratory, California Institute of Technology; and the Wright Brothers Lecturer, Abe Silverstein, Chief, Wind Tunnel and Flight Division, Lewis Flight Propulsion Laboratory, N.A.C.A., who spoke on "Research on Aircraft Propulsion Systems."

Honorary Fellowship in the Institute to: American—Clark B. Millikan, Acting Director, Guggenheim Aeronautical Laboratory, California Institute of Technology; Foreign—Capt. J. Laurence Pritchard, Secretary, The Royal Aeronautical Society.

Fellowship in the Institute to: American—H. Julian Allen, Aeronautical Engineer, Ames Aeronautical Laboratory, N.A.C.A.; Maurice A. Biot, Professor of Applied Physical Sciences, Brown University; Francis H. Clauser, Chairman, Aeronautical Department, The Johns Hopkins University; Oliver P. Echols, President, Aircraft Industries Association of America; C. C. Furnas, Director, Cornell Aeronautical Laboratory, Inc.; Carl Kaplan, Chief, Physical Research Division, Langley Aeronautical Laboratory, N.A.C.A.; Galen B. Schubauer, Chief, Aerodynamics Section, National Bureau of Standards; C. Richard Soderberg, Professor and Head, Mechanical Engineering Department, Massachusetts Institute of Technology; F. L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.

Charles H. Colvin, Chairman of the Nominating Committee.

National Meetings Calendar

March 18	Flight Propulsion Meeting, Cleveland
April 29–30	Personal Aircraft Meeting, Wichita, Kan.
May 24–26	I.A.S.-R.Ae.S. Conference, New York
July 21–22	Annual Summer Meeting, Los Angeles

For details see page 77

C.A.; Foreign—S. Goldstein, Professor, Department of Mathematics, University of Manchester, Manchester, England.

The Secretary announced that the Council had elected the following officers of the Institute for 1949: President, W. A. M. Burden; Vice-Presidents, J. L. Atwood, C. J. McCarthy, G. S. Schairer, and Elmer A. Sperry, Jr.; Director, S. Paul Johnston; Assistant Director, James L. Straight; Treasurer, Earl D. Osborn; Secretary, Robert R. Dexter; and Controller, Joseph J. Maitan.

ROBERT R. DEXTER, *Secretary*

President's Report, 1948

THE YEAR 1948 has been one of satisfactory growth for the Institute in spite of the relatively low level at which the airplane industry has been operating. Particularly gratifying is the fact that our staff has been able to increase the services of the Institute to members, while operating within a budgetary limit keyed to reduced industrial activity. During the year, net membership has increased, dues have been paid promptly, and an all-time record has been established in the number of Section and Student Branch meetings held. Two new Sections have been inaugurated in the past 12 months—one at Chicago, the other at Columbus.

This year, small increases in dues for certain membership classifications have been made and found acceptable by the membership at large, and a logical and uniform structure of corporate dues related to gross aeronautical sales has been established and likewise found acceptable by Corporate Members. A continuation of our primary contract for a Standard Aeronautical Indexing System has been received, the work completed by Mr. Neville and his staff being highly satisfactory to the contracting agency.

Perhaps the Institute's most important recent activity has been the final fruition of the work inaugurated in 1944 by our then President, Reuben H. Fleet, through whose efforts very substantial sums of money were raised for Institute buildings in Los Angeles and San Diego. Wartime restrictions prevented the Institute from proceeding with the buildings at the time the original funds were made available, and increases in building and operating costs that have occurred since that time have made the budgetary problems of completing and operating the buildings difficult of solution.

Thanks to the generous additional donations made by West Coast companies, the cooperation of architects and planners in reducing building costs, and the fine work done by individual members of the Los Angeles and San Diego Sections and staff members on the East and West Coast, practical solutions were found which permitted the inauguration last fall of construction both at San Diego and Los Angeles, and both buildings are expected to be ready for use by the summer of 1949. These new facilities will greatly increase the service rendered to members on the West Coast, the Los Angeles building being designated as Western Headquarters of the Institute.

In closing my term of office I recommend to our new officers the businesslike and thorough methods of our staff and their wideawake efforts to give ever increasing service per dollar expended in Institute affairs.

JOHN K. NORTHROP, *President*

Treasurer's Report

FOR THE YEAR ENDING September 30, 1948, the Institute had an income of $275,957.43 with expenses totaling $278,910.95. Therefore, we had a deficit of a fraction more than 1 per cent of income or $2,953.52. This small deficit was caused principally by increased costs of about everything. For example, the REVIEW cost $7,000 more to publish than last year. General operating expenses were up $4,000.

Our last year's small loss could have been eliminated by reducing the Institute services to industry and its engineers. However, these are times when Institute services should be increased, not reduced. By having the Institute assemble data at one source, individuals and companies are able to secure information at a portion of the cost of maintaining individual data sources. As an additional service this year, we issued the ROSTER OF MEMBERS at a net cost of only $500 including printing, editorial, promotion, etc. Another new service, the AERONAUTICAL ENGINEERING INDEX, was started during the year, and this publication will be issued annually.

For the next fiscal year, a balanced budget has been worked out and will be adhered to. From results to date and reasonable forecasts, the increase in income should more than offset last year's deficit.

Our corporate dues structure has been put on a formula basis in an attempt to divide fairly the corporate dues and to permit many smaller corporations to become Corporate Members.

From the reports of other officers, you can see that improved relations have been developed between local sections and the National Office and that the size and quality of technical papers published and presented at meetings is increasing.

These increased services have been accomplished in the face of increased costs and reduced income by the efficiency and extra effort of the Director and his entire staff. Within next year's balanced budget, plans are being formulated for increased Institute activities. These plans will be possible only by the continued exercise of every economy.

Additional contributions and pledges have been received for the Los Angeles and San Diego Institute buildings to an extent where it now appears that these buildings will be completed with building funds on hand or pledged. These funds include a sum of $30,000 authorized by the Council for assistance in completing the Los Angeles building, which will be the West Coast headquarters of the Institute. When completed the buildings will have cost over one-half million dollars. Our fine buildings on both coasts are a visible indication of the stability and growth of this 17-year-old society.

Our books were examined by Harris, Kerr, Foster and Company, Certified Public Accountants. An abstract of their certified statement is published in this issue of the REVIEW.

SHERMAN M. FAIRCHILD, *Treasurer*

INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

Statement for the fiscal year October 1, 1947, to September 30, 1948

Consolidated Balance Sheet and Operating Statement

ASSETS

General Fund Assets:		
Cash on Deposit and Petty Cash	$ 48,643.31	
Accounts Receivable—Net	22,843.10	
Advances on Contracts	24,758.24	
Deposits and Prepayments	7,820.05	
Furniture and Fixtures	5,000.00	
Investment Accounts:		
Benefactor Membership Fund:		
U.S. Treasury Bonds	52,345.60	
Reserve Fund:		
U.S. Treasury Bonds	174,000.00	
Daniel Guggenheim Park (Assessed Value—$454,450.00)	1.00	
Books, Prints, Models, Medals, etc.	1.00	
Aeronautical Index	1.00	
Total General Fund Assets		$335,413.30
Restricted Fund Assets:		
The Thurman H. Bane Award Fund	$ 1,200.00	
The Sherman M. Fairchild Fund	27,268.59	
The Paul Kollsman Fund	69,000.00	
The Vernon Lynch Award Fund	35,947.69	
The Minta Martin Aeronautical Fund	524,429.40	
The Pacific Aeronautical Library Fund	11,102.90	
The Sylvanus A. Reed Award Fund	13,358.28	
The Lawrence Sperry Award Fund	13,124.18	
New York Building Maintenance & Reserve Fund	324,940.50	
Los Angeles Building Fund	353,241.56	
San Diego Building Fund	175,017.64	
Total Restricted Fund Assets		$1,548,630.74

LIABILITIES, FUNDS, AND UNEXPENDED INCOME

General Fund:		
Accounts Payable	$ 14,780.65	
Deferred Credits to Income (Dues & Subscriptions)	70,925.85	
Withholding Taxes	1,608.85	
Reserve	175,391.98	
Unexpended Income:		
Balance September 30, 1948	72,705.97	
Total General Fund Liabilities and Unexpended Income		$335,413.30
Restricted Funds:		
Principal of gifts and unexpended income (See Assets)		
Total Restricted Funds Liabilities		$1,548,630.74

Statement of Income and Expenses

General

INCOME		
Dues (less subscriptions)	$120,394.05	
Entrance Fees	3,420.00	
Interest on Investments	7,636.82	
Miscellaneous	218.29	
Excess of Income over Expenses:		
Journal of the Aeronautical Sciences	3,026.29	
Aeronautical Engineering Catalog	3,181.79	
Total Income		$137,877.24
EXPENSES		
Administrative and Clerical Salaries	$ 90,288.02	
General Office Expenses—Net	32,400.24	
Excess of Expenses over Income:		
Library Costs	15,027.13	
Aeronautical Engineering Review	3,115.37	
Total Expenses		140,830.76
Net Operating Loss for the Period Ending September 30, 1948		$ 2,953.52

Review

INCOME		
Advertising Revenue	$ 73,393.41	
Subscriptions	16,861.62	
Total Income		$ 90,255.03
EXPENSES		
Editorial and Clerical Salaries	$32,075.47	
General and Publication Expenses	61,294.93	
Total Expenses		93,370.40
Excess of Expenses over Income (See General Expenses)		$ 3,115.37

Journal

INCOME		
Subscriptions	$ 28,856.47	
Total Income		$ 28,856.47
EXPENSES		
Editorial and Clerical Salaries	$ 4,913.83	
General and Publication Expenses	20,916.35	
Total Expenses		25,830.18
Excess of Income over Expenses (See General Income)		$ 3,026.29

Catalog

INCOME		
Advertising Revenue	$23,276.00	
Sales and Reprints	175.77	
Total Income		$23,451.77
EXPENSES		
Editorial and Clerical Salaries	$ 7,881.35	
General & Publication Expenses	12,388.63	
Total Expenses		20,269.98
Excess of Income over Expenses (See General Income)		$ 3,181.79

I.A.S. Officers for 1949

President
W. A. M. Burden
Specialist in Aviation,
Smith, Barney & Company

Vice-President
J. L. Atwood
President, North American
Aviation, Inc.

Vice-President
C. J. McCarthy
Vice-President, United Aircraft
Corporation

Staff Officers for 1949

S. Paul Johnston, Director

James L. Straight, Assistant
Director

Robert R. Dexter, Secretary
Joseph J. Maitan, Controller

Vice-President
G. S. Schairer
Staff Engineer, Boeing Airplane
Company (Seattle)

Vice-President
Elmer A. Sperry, Jr.
Vice-President and Treasurer
Sperry Products, Inc.

Treasurer
Earl D. Osborn
President, Edo Corporation

Director's Report

FOR THE PAST SEVERAL YEARS the reports of the Director to the Council and the Membership have been largely concerned with the financial position of the Institute. During the immediate postwar period, it was feared by some that the organization might have to draw heavily on its somewhat slender reserves simply to maintain the *status quo*. The only thing that I wish to report on that subject at the present time is to point out that for the past 3 fiscal years the Institute has been operated on a practically break-even basis. In 1947 we were "in the black." This year, as you will note from the Treasurer's statement, we have incurred a small operating loss because of the general increase in cost of goods and services all the way along the line. The budget for the current year is set up for a break-even final statement.

Membership and Meetings

During this period of readjustment the most important thing that has happened has been a general increase of all I.A.S. services rather than any curtailment. The best evidence of progress in any society such as ours is to be read in its membership and general activities records. People simply do not want to belong to any organization that does not render services commensurate with its cost.

It has never been Institute policy to undertake any sort of "drive" or campaign for membership. We believe that the Institute itself is its own best sales argument. The Secretary's report on Membership is revealing.

MEMBERSHIP BREAKDOWN COMPARISONS BY CALENDAR YEAR

	Dec. 31, 1946	Dec. 31, 1947	Dec. 31, 1948
Temporary Honorary Members	20	18	21
Honorary Fellows	19	21	20
Fellows	173	179	185
Associate Fellows	556	577	600
MEMBERS	2,119	2,781	2,981
Associate Members	329	405	416
Technical Members	3,263	2,728	2,908
Totals	6,479	6,709	7,131
Student Members	1,655	3,300	4,068
Totals	8,134	10,009	11,199

During all this time, there has been no slacking-off of membership requirements. If anything, the Membership Committee policy has been to maintain quality by the careful screening of new applications and of applications for regrading.

The year 1948 was one of the most active in our history, with an I.A.S. meeting of some sort *every three days*, on the average, the year around. One of the most important meetings scheduled for 1949 is international in character. It will be the second joint meeting with The Royal Aeronautical Society. It is scheduled for New York and vicinity for May 24–June 6.

Our Section activities are expanding. We are trying to assist the Section work in every possible way. The Director and the Secretary plan at least one visit to each Section in the country in the course of this year. We have already had many profitable meetings so far.

The table below from the Secretaries' records indicates the general level of activity in our Sections and Student Branches.

I.A.S. SECTIONS AND STUDENT BRANCHES

	Dec. 31, 1946	Dec. 31, 1947	Dec. 31, 1948
Number of Sections	13	17	19
Number of Section Meetings	72	92	121
Number of Members in Sections	4,166	4,734	5,032
Number of Branches	38	51	60
Number of Branch Meetings	210	277	327
Number of Student Members	1,655	3,300	4,068
Branch Award Winners	16	42	41

Publications

Continuous effort has been placed on the improvement and the expansion of all our publications. In spite of constantly rising production costs we have been able to publish more pages in both the JOURNAL and the REVIEW this year than last. We shall continue to add more pages of technical articles and reviews as fast as our income situation warrants.

A readership survey that was made on the REVIEW showed gratifying results. Some 36 per cent of the entire I.A.S. membership sent in comments and criticisms of the magazines which have been most helpful in determining policies for the future.

The CATALOG is being continued. The prospects for a "break-even" operation on it are excellent for the coming issue.

The I.A.S. ROSTER OF MEMBERS, a much needed item, was added to our list this year. It was made practically self-supporting by the sale of a limited number of advertising pages. The 1949–1950 edition is now in preparation.

The operation of our Preprint and Reprint departments under the Sherman M. Fairchild Publication Fund has been expanding rapidly. During the fiscal period ending September 30, that department actually distributed to members at nominal cost over 12,000 copies of technical reports and papers, including some 62 separate titles. Since September, the number has been greatly increased. This service has been of great benefit to I.A.S. members.

Library Services

The usage of I.A.S. Library Services on both East and West coasts continues to expand, although the full potential has not yet been reached.

A statistical study of the New York activity shows:

	1947	1948
Loans	2,197	2,973
Photostat Articles Supplied	287	576
Readers	805	837
Telephone Calls for Information	793	806
Books Added	1,276	1,340
Bound Periodicals Added	318	372
Total Volumes in New York and Los Angeles Libraries	34,970	34,145*

* Approximately 2,165 duplicates were sold in 1948.

Standard Aeronautical Indexing System

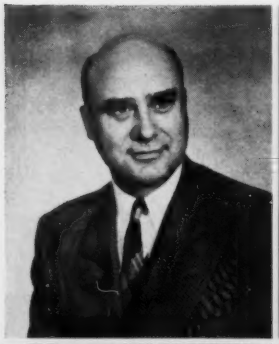
The work on the S.A.I.S., started in 1947, has been continued on only a slightly reduced scale throughout 1948. Our contract with the Air Materiel Command at Wright Field has been extended to August, 1949. We hope that means will be found to carry on at least a limited program of continuation beyond that date.

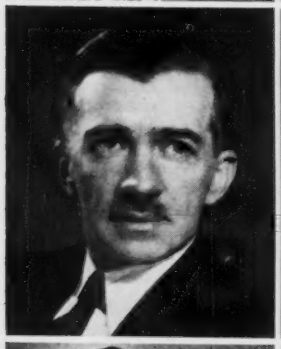
Aeronautical Archives

As a result of increasing interest on the part of a number of I.A.S. members in the historical aspects of the Institute, the Aeronautical Archives Committee was reactivated under the Chairmanship of William A. M. Burden. A new grade of membership, "Historical Associates," has been authorized by the Council, and a small budget has been set up for a full-time Curator at the Museum and a modest publication program to serve the needs of this group.

West Coast Building Program

Nineteen forty-eight will be remembered as the year in which the West Coast building programs came to fruition. Authorized by the Council and under strictly controlled construction and operations budgets, the I.A.S. buildings at Los Angeles and San Diego have been started. Occupancy for both is scheduled for late Spring.





Newly Elected Members to the Institute Council

Eastern Area

D. R. Shoults, Vice-President —Engineering, The Glenn L. Martin Company.

H. Russell Young, President, Young Testing Machine Company.

Central Area

Willson H. Hunter, Chief, Icing Research Branch, Wind Tunnel and Flight Division, Lewis Flight Propulsion Laboratory, N.A.C.A.

George H. Tweney, Associate Professor, Department of Aeronautical Engineering, Wayne University.

Western Area

R. G. Folsom, Professor of Mechanical Engineering, University of California at Berkeley.

Willis M. Hawkins, Chief Preliminary Design Engineer, Lockheed Aircraft Corporation.

Council Members

P. R. Bassett, President, Sperry Gyroscope Company.

Luis de Florez, President, de Florez Engineering Company.

Sherman M. Fairchild, Head of Sherman Fairchild & Associates.

J. S. McDonnell, President, McDonnell Aircraft Corporation.

R. G. Robinson, Assistant Director of Aeronautical Research, N.A.C.A.

General

After almost 8 years of service on the Institute staff, our Executive Vice-President, Bennett H. Horchler, resigned as of January 1. He has made great contributions to the work of the organization during his time with the I.A.S. The staff extends to him its best wishes for success in his new work.

The post of Executive Vice-President, which has been held by Mr. Horchler will not be filled as such. James L. Straight, who has served for the past 2 years as Manager of our Western Region, has been appointed Assistant Director of the Institute, to be an officer of the Institute and to represent the Director in all phases of our activity on the West Coast. The Western Region (which encompasses a considerable percentage of our membership, both individual and Corporate) will thus have a resident executive officer who will be empowered to act for the Director.

In conclusion, I want to extend my personal thanks to the entire staff of the Institute. No head of any organization could have been given more loyal support and intelligent cooperation than has been given me here since I came aboard. To my personal assistant, Marjorie Rode; to Bob Dexter, our Secretary; to Joe Maitan, who watches our finances with an eagle eye; to Welman Shrader, Director of Publications; and to all the other men and women who really do all the work of the Institute, I express my sincere thanks. If we have had any measure of success in this operation, the credit belongs to them.

S. PAUL JOHNSTON, *Director*

I.A.S. General News

Flight Safety Foundation Tally of Accomplishments

In a year-end report, Director Jerry Lederer, of Flight Safety Foundation, listed nine contributions to aviation safety made by the Foundation last year.

▸ **Safety Accomplishments**—The list drawn up by Mr. Lederer included the following:

- Establishment of interchange service for channeling accident and near-accident experience data.
- Forum conducted in which operators and aeronautical engineers exchanged ideas on internal company policy relating to safety.
- Seminar held for civilian aircraft investigator training—first of its kind in this country and probably in the world.
- Advised marine captains as to procedures recommended for use when an aircraft prepares to ditch in vicinity of merchant vessel.
- Cooperation with Coast Guard in training pilots in ditching methods.
- Completed first integrated study of scientific methods for evaluating flight-crew requirements for large transport planes.
- Contract signed with C.A.A. to develop this study.
- Research project established to study cockpit simplification and reduction of cause of fatal accidents in small personal planes.
- Cooperation with civic organizations for promotion of safety projects.

Curtiss-Wright Officers Receive Certificate of Merit

Secretary of Air Force W. Stuart Symington presented to a group of officials of Curtiss-Wright Corporation and its engine-building division, Wright Aeronautical Corporation, the President's Certificate of Merit in recognition for their wartime services at a luncheon in Washington, D.C.

▸ **Six I.A.S. Members**—Aviation leaders receiving the award were: Guy W. Vaughan, Associate Member and Chairman of the Board of Curtiss-Wright and Wright Aeronautical, who was President of both companies during the war when the organization set its all-time production record; William K. Ebel, a Fellow and Chief Engineer of Curtiss-Wright Airplane Division, formerly of The Glenn L. Martin Company, "for the engineering and development of military aircraft" (while at Martin); C. C. Pearson, a Member and Vice-President of Curtiss-Wright, formerly of Douglas Aircraft Company, Inc., "for the mass production of military aircraft" (while at Douglas); Burdette S. Wright, a Member and former Curtiss-Wright Vice-President, "for the mass production of military aircraft" while General Manager, C.-W. Airplane Division; and Raymond W. Young, a Member and Vice-President in Charge of Engineering for Wright Aeronautical, "for the production of aircraft engines."

Not present at the luncheon was William D. Kennedy, an Associate Fellow and former Curtiss-Wright Vice-President and former Vice-President and General Manager of Wright Aeronautical, who was scheduled to be awarded the honor "for the construction of aircraft engines" but was unable to arrive from London in time to attend the ceremonies.

Both Mr. Kennedy and Mr. Wright retired in January, 1949, when the election of four new directors by the Curtiss-Wright Board of Directors took place.

Gain of 600 New Members Expected on West Coast

In a report to the I.A.S. Council, January 26, Assistant I.A.S. Director Jim Straight said that with the new facilities in San Diego and Los Angeles being completed for occupancy on April 1 and June 1, respectively, and with the Membership Committees of both cities mounting a new membership drive, he felt "safe in predicting that San Diego will add at least 200 new members in 1949, and that Los Angeles will add at least 400."

▸ **New Corporate Members**—Furthermore, the Assistant Director went on, the opportunity for enlisting new Corporate Members is getting similar new emphasis.

"At Los Angeles alone," Mr. Straight said, "we have more than 300 prospects for Corporate Membership, all having a definite interest in the advancement of aeronautics. I believe we should be able to enlist 50 new Corporate Members this year.

Mr. Straight called the erection of the new buildings at San Diego and Los Angeles "an adventure" because it is without precedent in professional society work. "No comparable society has such a tool," he declared, "and, of course, there are few professions that afford such a concentration of activity and membership as one finds in Southern California."

Mr. Straight was elected Assistant Director of the Institute at the Council Meeting last January during the Annual Meeting. He will continue to make his headquarters in Los Angeles.

Presidential Awards to Boeing Executives

Three Boeing Airplane executives have been awarded the President's Certificate of Merit for service during the last war, in addition to one awarded posthumously to Philip G. Johnson, former Boeing President.

Honored were Wellwood E. Beall, Vice-President—Engineering and Sales, C. L. Egtvedt, Chairman of the company, both I.A.S. Fellows, and E. C. Wells, Vice-President—Engineering, a Member.

It was the first presentation by the Air Force of this type of award in the Northwest.

Hughes Aircraft Announces Hughes Fellowship Program

Howard Hughes Fellowships in Creative Aeronautics have been announced by the Hughes Aircraft Company, Culver City, Calif. The Fel-

(*Continued on page 17*)

Honors Night Highlights

General Kuter, M.A.T.S. Commander, Gives Details of Airlift That Saved World from War Last June; Four I.A.S. Annual Awards Presented to Outstanding Aeronautical Scientists by Northrop; Clark Millikan Made 1948 American Honorary Fellow; Laurence Pritchard, Foreign Honorary Fellow.

IN A SPEECH before the nation's foremost aeronautical scientists and industry leaders attending the I.A.S. Annual Honors Night Dinner, Hotel Astor, January 24, Major Gen. Laurence S. Kuter, Commander, Military Air Transport Service, gave details of the Berlin Airlift, which saved the world from war when the Russians shut off land and water routes connecting Western zones with the German capital in June, 1948. (Excerpts from General Kuter's speech are given on page 24.)

▶ **Navy-Air Force Integration**—General Kuter, following a review of the primary activities of M.A.T.S. since its inception and formal organization June 1, 1948, described the measure of integration achieved between Navy and Air Force personnel. M.A.T.S., he said, has proved that "integration in the Armed Services can and does work to the decided advantage of all concerned."

General Kuter also gave an analysis of the distinctions between scheduled air transport service and strategic airlift of the Berlin type, which at present is the major effort of M.A.T.S.

▶ **25-Ton Cargo Plane Needed**—The future of strategic airlift, General Kuter declared, lies in the development and production of the proper transport aircraft, a big plane with the right characteristics.

"In my opinion," the M.A.T.S. commander said, "these include: ease of maintenance; high utilization; direct loading and unloading; maximum useful capacity, probably 25 tons; a range of 3,000–4,000 miles; and a low cost of operation."

Speed of such a cargo plane was set by the General at about 250 m.p.h. However, he added, in this era of jet and supersonic speeds it is important not to transfer this emphasis on speed to the field of air transport, where it is a secondary consideration.

▶ **————'s Arctic Winter**—Jack Northrop, retiring President, who conducted the program at the Dinner, opened with the remark that "Those of us who have come from the West Coast for this celebration feel ourselves doubly fortunate tonight in having exchanged the rigors of the (censored) arctic winter for the comparatively balmy climate and bright sunshine of New York City."

Mr. Northrop drew a comparison of the yagaries of the climate "to the heated and frigid blasts of activity, or the lack thereof, which stem from a completely unpredictable fluctuation in the market for our services." Following an almost unanimous approval by both houses of Congress for a 70-group Air Force, Mr. Northrop said, one might have expected a reasonably stable period to prevail in the aeronautical industry. Now, however, the frigid winds of cut back and uncertainty are again abroad.

"Let us hope," Mr. Northrop said, "that the breezes of spring will reveal the present blizzard to be as unusual and impermanent as the (censored) snows."

▶ **Steady Improvement**—The Institute, the retiring President declared, has had a year of steady advancement; it has operated within its predicted income, and, in addition, means were found to bring to fruition the great work started in 1944 in the shape of the Los Angeles and San Diego buildings.

The Los Angeles headquarters, Mr. Northrop said, will be finished in time for the Institute's Annual Summer Meeting, a feature of which will be a trip to San Diego to help San Diego Section members formally dedicate their new building.

▶ **Highest I.A.S. Award**—Presentation of the four awards annually made by the I.A.S. to outstanding scientists for their contributions to the advancement of aeronautics was made by Mr. Northrop to George W. Brady, Curtiss-Wright Propeller Division, for the reversible-pitch propeller; to Dr. W. Randolph Lovelace, II, Lovelace Clinic, for aero-medical contributions; to Allen E. Puckett, Cal Tech, for wind-tunnel designs; and to Paul A. Humphrey, U.S. Weather Bureau, for meteorological contributions (see Award Winners, pages 14–15).

The highest Institute award, the Honorary Fellowship, went to Dr. Clark B. Millikan, Acting Director, Guggenheim Aeronautical Laboratory, Cal Tech, and to Capt. J. Laurence Pritchard, Secretary, The Royal Aeronautical Society.

Because Captain Pritchard was unable to be present at the Dinner to receive the 1948 Foreign Honorary Fellowship, formal presentation of this highest I.A.S. honor will be made on the occasion of the I.A.S.-R.Ae.S. Conference to be held May 24–26 in New York, which Captain Pritchard will attend.

In addition, nine American Fellows were selected for 1948: Maurice A. Biot, Brown University; Francis H. Clauser, The Johns Hopkins University; Oliver P. Echols, A.I.A.; Dr. C. C. Furnas, Cornell Aeronautical Laboratory, Inc.; Carl Kaplan, Langley Aeronautical Laboratory, N.A.C.A.; Galen B. Schubauer, National Bureau of Standards; F. L. Thompson, Langley Aeronautical Laboratory, N.A.C.A.; H. Julian Allen, Ames Aeronautical Laboratory, N.A.C.A.; and C. Richard Soderberg, M.I.T. The latter two were unable to be present at the Honors Night Dinner.

The Foreign Fellowship was extended to Dr. Sydney Goldstein, University of Manchester, U.K., 1947 Wright Brothers Lecturer.

Dr. Goldstein, who also was unable to attend the Dinner, sent a cable, which Mr. Northrop quoted as follows:

"I was very happy to learn of my election as a Fellow of the Institute... Thank you for your cable. . .With all good wishes," Sydney Goldstein.

▶ **Burden Inducted**—Final official duty of Mr. Northrop was to turn over to his successor, William A. M. Burden, the Presidency of the Institute.

Mr. Burden, in a short address, declared that the outlook "is promising for a year of real progress in the affairs of your society. . . .

"But the less we talk, the more we can work," Mr. Burden concluded, "and as a practical contribution toward brevity I hereby declare this meeting adjourned."

and Spotlights

Scenes at the Astor: *Wright Aeronautical's intrepid photographer, provided for the occasion through the courtesy of the Wright Aeronautical Corporation, obtained these interesting pictures of the Honors Night Dinner and Reception. (Upper left): Retiring President John K. Northrop presents the 1948 American Honorary Fellowship Certificate to Dr. Clark B. Millikan. (Upper right): Allen E. Puckett receives The Lawrence Sperry Award from Mr. Northrop. (Center views): Speakers' table, Honors Night Dinner. (Lower left): George W. Brady is congratulated by 1949 I.A.S. President W. A. M. Burden upon his winning of The Sylvanus Albert Reed Award. (Lower right): Winners of 1948 Awards, Paul A. Humphrey, George W. Brady, W. Randolph Lovelace, II, and Allen E. Puckett, receive congratulations from Past-President John Northrop.*

I.A.S. Awards and

W. Randolph Lovelace, II, M.D., Head of Section on Surgery, Lovelace Clinic.

Paul Armstrong Humphrey, Meteorologist, U. S. Weather Bureau.

The John Jeffries Award

Honoring the memory of Dr. John Jeffries, an American physician who, with Blanchard, the French balloonist, made the first aerial voyage across the English Channel in 1785 and on a previous voyage made the earliest recorded scientific observation from the air, this award was established by the Institute in 1940 to give recognition to the importance to aviation of scientific endeavor in the field of medicine.

Presented to W. RANDOLPH LOVELACE, II, M.D.

"For outstanding contributions to the advancement of aeronautics through medical research."

Dr. Lovelace, who has been active in aviation medical research since 1938, collaborated in the development of the BLB (Boothby-Lovelace-Bulbulian) oxygen mask for oxygen therapy and high-altitude flying which is proving of great value in this country and abroad.

During the war, as Chief of the Aero Medical Laboratory, Engineering Division, Wright Field, Dayton, Ohio, Dr. Lovelace was responsible for directing research and development as it applied to the determination of the effect of flight on the human organism. Under his supervision, recommendations were made regarding methods or means of eliminating effects of deleterious nature which adversely influenced the efficiency, health, or safety of flying personnel. He also participated in numerous high-altitude test flights involving testing of oxygen equipment and pressure cabin aircraft up to altitudes of 44,980 ft. and initiated studies on parachute opening shock at the various altitudes.

Receiving the degree of M.D. in 1934, Harvard University Medical School, Dr. Lovelace is a Fellow, American College of Surgeons, International College of Surgeons, Aero Medical Association, and the Institute of the Aeronautical Sciences.

The Robert M. Losey Award

Established in 1940, this award honors the memory of Capt. Robert Moffatt Losey, a member of the Institute and a meteorologic officer of the Air Corps, who was killed at Dombas, Norway, April 21, 1940, while serving as an official observer for the U.S. Army. He was the first officer in the service of the United States to die in World War II.

Presented to PAUL ARMSTRONG HUMPHREY

"In recognition of outstanding contributions to the science of meteorology as applied to aeronautics."

Paul Humphrey was born in Memphis, Tenn., where he received most of his education. Entering the Weather Bureau in 1939, he advanced through the various grades to his present position of Meteorologist at the Central Office, Washington, D.C.

During the war, while serving with the Navy as Aerological Officer, he participated in many hazardous weather reconnaissance flights. His outstanding work was in the development of typhoon reconnaissance in this period, and he was responsible principally for the Navy aerological publication, *Typhoon Weather Reconnaissance*, containing his drawings of typhoon structure.

In 1947 he was assigned to Joint Task Force SEVEN as Assistant Staff Meteorologist in association with Col. Benjamin G. Holzman, U.S.A.F., winner of the 1947 Losey Award, in connection with the Bikini atomic bomb tests.

At the time of the presentation of the award, Mr. Humphrey had just completed the aerological annex of the final report of the atomic tests conducted last spring, in which he participated on detail to the Air Force.

Honors for 1948

George W. Brady, Chief Engineer, Propeller Division, Curtiss-Wright Corporation.

Allen E. Puckett, Chief, Wind Tunnel Section, Jet Propulsion Laboratory, Calif. Inst. of Tech.

The Sylvanus Albert Reed Award

For a notable contribution to the aeronautical sciences resulting from experimental or theoretical investigations, the beneficial influence of which on the development of aeronautics is apparent.

The late Dr. S. A. Reed, designer of metal aircraft propellers and a Founder Member of the Institute, made an endowment to the Institute in 1933 to provide an annual award with a certificate and honorarium of $250. The recipient of this award is chosen by ballot of the American Honorary Fellows of the Institute, who now number more than 160 of this country's leading aeronautical scientists.

Presented to GEORGE W. BRADY

"For his contribution to the development of the reversing propeller resulting in shorter landing runs for large aircraft."

As Chief Engineer of Curtiss-Wright's Propeller Division, George Brady headed up the development program of the reversible propeller which has added to the safety of operation of multiengined airplanes.

Born in Indianapolis, Ind., on August 22, 1903, George Brady took his Ph.B. at Yale University in 1925, and M.S. at M.I.T. 2 years later.

He joined The Glenn L. Martin Company as a Draftsman in 1926 and the following year accepted the position as Junior Engineer at Chance Vought Corporation where he remained until 1931, being promoted in the meantime to Project Engineer. American Airlines then made him Design Engineer, and the following year he was in the same capacity at Warren Engineering Company. He joined Curtiss-Wright's Propeller Division in 1935 as Design Engineer and was made Chief Engineer in 1938.

The Lawrence Sperry Award

For a notable contribution made by a young man to the advancement of aeronautics.

This award was endowed in 1936 by the sister and brothers of the late Lawrence Sperry, pioneer aviator and inventor, who died in 1923 at the age of 31. It provides an annual certificate of citation and honorarium of $250 to the recipient selected by the Board of Award.

Presented to ALLEN E. PUCKETT

"For outstanding contributions to the design and development of supersonic wind tunnels."

Allen E. Puckett, who was born July 25, 1919, in Springfield, Ohio, participated in the design of the California Institute of Technology's $2\frac{1}{2}$-in. supersonic wind tunnel, which first operated in 1941 at a Mach Number of 4.4. This tunnel, which was the pilot tunnel for Aberdeen supersonic tunnel, is believed to have been the first closed circuit, continuously operating, high Mach Number, supersonic tunnel in the United States. He also was responsible for, and is now in charge of, the 12-in. supersonic wind tunnel at the Cal Tech Jet Propulsion Laboratory and of the 20-in. tunnel presently under construction. In addition, he consulted and advised extensively on the supersonic wind tunnels of the Ordnance Aerophysics Laboratory at Daingerfield and of the Air Materiel Command at Wright Field.

Mr. Puckett was graduated from Harvard University with a B.S. in 1939, and received an M.S. in Mechanical Engineering at Harvard in 1941. He has been employed at Cal Tech since 1941.

1948 I.A.S. Fellows

American Fellows

H. Julian Allen, Aeronautical Engineer, Ames Aeronautical Laboratory, N.A.C.A.

Maurice A. Biot, Professor of Applied Physical Sciences, Brown University

Francis H. Clauser, Chairman, Aeronautical Department, The Johns Hopkins University

©Fabian Bachrach

Oliver P. Echols, President, Aircraft Industries Association of America

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C. C. Furnas, Director Cornell Aeronautical Laboratory, Inc.

Carl Kaplan, Chief, Physical Research Division, Langley Aeronautical Laboratory, N.A.C.A.

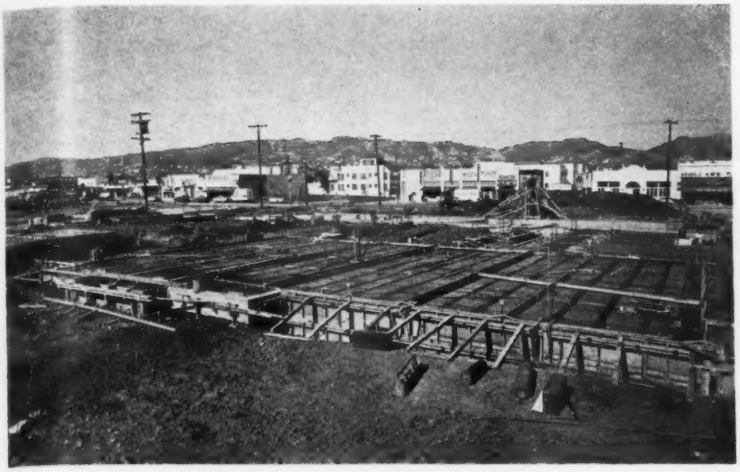
Galen B. Schubauer, Chief, Aerodynamics Section, National Bureau of Standards.

C. Richard Soderberg, Professor and Head, Mechanical Engineering Department, Massachusetts Institute of Technology.

F. L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.C.A.

Foreign Fellow

S. Goldstein, Professor, Department of Mathematics, University of Manchester, Manchester, England.



LOS ANGELES I.A.S. BUILDING TO BE READY JUNE

View looking northwest on Beverly Blvd. and Stanley St., Los Angeles, taken last January 3, of the Los Angeles Section Building's foundations. Building is scheduled for completion in June and will be used for the Annual Summer Meeting sessions July 21–22.

(*Continued from page 11*)

lowships are established for the purpose of aiding in the development of high-quality research engineers for advanced development work in the aircraft industry. It is believed, Hughes Aircraft says, that the combination of advanced theoretical training and industrial tutorial training represents an ideal process for the education of the creative engineer.

▸ **12-Month Program**—The Fellowship will constitute a 12-months' program, a portion of which will be spent in advanced development work at the Hughes plant and the remainder in study toward the Doctor's degree or in advanced research at California Institute of Technology.

Fellowships are open to any American citizen whose technical background and qualifications will admit him to graduate standing at Cal Tech with the eventual aim of obtaining Ph.D. with a major in Aeronautics or Physics and a minor in the other.

It will be required generally that a candidate shall have had a year or more of postgraduate work, but exceptional men with no graduate study beyond the Bachelor's degree will be considered. Further details as to qualifications may be obtained from the Cal Tech Catalog.

Vernal Meetings

Two professional societies announce meetings in the Spring: the American Institute of Electrical Engineers Conference on the Industrial Application of Electron Tubes, Hotel Statler, Buffalo, N.Y., April 11–12; and the Spring Meeting of the Society for Experimental Stress Analysis, Hotel Statler, Detroit, Mich., May 19–21.

Gifts to the Institute Collections

Allan D. Emil added to his previous generous gifts copies of the Bodoni press book, *Opuscoli di Agostino Gerli*, Parma, 1785; *Collegium Experimentale sive Curiosum*, by Johannes Christophorus Sturmius, Nuremburg, 1676; and *Antologia dell' Arte Pittorica*, by Antonio Raffaelo Mengs, Augusta, 1784. G. Tilghman Richards, of London, sent a special compilation of technical and pictorial data on the historical and technical development of the Lee-Richards Annular Monoplane. Eight technical bibliographies were received from the Bureau of Ships of the U.S. Navy Department. The Royal Aeronautical Society presented several copies of the reprint of the lecture by Peter G. Masefield on "Some Economic Factors in Civil Aviation." Several papers on navigation and the 1948 report of its Committee on Standards for Air were received from the Institute of Navigation. N.A.C.A. *Technical Notes* were received from the Republic Aviation Corporation through the courtesy of Mrs. George Burrell. Technical reports and several hundred aeronautical house organs were received from the Cornell Aeronautical Laboratory, Inc., through the courtesy of Miss Elma T. Evans.

Additional gifts were received from *Air Force;* the British Joint Services Mission; Iowa State College; Purdue University; Rocket Engineering Company; the U.S. Bureau of Mines; National Bureau of Standards; Post Office Department; State Department; Weather Bureau; Congressional committees on appropriations, armed services, commerce, interstate and foreign commerce, merchant marine and fisheries, and veterans' affairs; and the House and Senate document rooms.

W. A. M. Burden Continues Library Gifts

W. A. M. Burden's generous gifts in previous years of large sections of his outstanding aeronautical library to I.A.S. are well known. This year he has made an additional gift of books, periodicals, and pamphlets valued at approximately $4,000. The collection includes special congressional aviation hearings, files of appropriations committee hearings and annual reports of Government departments, pamphlets on aerial photography, aviation medicine, air navigation, and other scientific and technical subjects, about 3,000 unbound periodicals, and 741 books on all aspects of aeronautics. An unusual feature of the col-

SAN DIEGO I.A.S. BUILDING NEARS COMPLETION

Construction of the new San Diego I.A.S. Building is expected to be completed about April 1, with occupation by the San Diego Section following close on the heels of the departing contractor. Greatly expanded activity within the San Diego area is expected with the new and beautiful facilities available to Institute members.

Silicone News

DC SILICONES

SILASTIC* INSULATED WIRE AND CABLE

Now Available for High Temperature High Voltage Applications

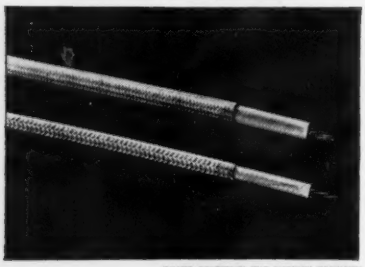


PHOTO COURTESY THE OKONITE COMPANY

Silastic is extruded over wire and cable ranging from No. 18 to 500,000 circular mils in size to provide insulation having maximum resistance to heat, ozone and weathering.*

Silastic* has been chosen to insulate the new line of heat-stable "Okotherm" wire and cable made by the Okonite Company of Passaic, N. J. Silastic* insulation maintains its high dielectric strength even after continuous long time exposure to temperatures as high as 200° C. (400° F.). Its dielectric loss factor is low compared with that of organic rubbers.

Silastic* insulation is practically unaffected by corona or ozone. A severe corona resistance test of Silastic 181 for example, was discontinued after more than 4000 hours without breakdown. The best organic rubber insulating materials break down under this same test in 50 to 150 hours.

Silastic* insulated wires and cables withstand severe outdoor weathering without deterioration because of exceptional water repellency, low moisture absorption, resistance to oxidation and flexibility at low temperatures. Serviceable operating temperatures range from —80° to +400° F.

These properties plus good resistance to a variety of chemicals and hot oil are now available to you in Silastic* insulated wire and cable. Among the many high temperature applications for Silastic* insulated wire or cable are: power plant wiring and lead wire for electric ovens, furnaces and motors.

Other applications include wiring for high intensity floodlights and street lights, and as high voltage ignition and neon sign cable. Our specifications for Silastic* insulated wire and cable are given in pamphlet No. G 6-S.

*TRADEMARK DOW CORNING CORPORATION

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Dow Corning
FIRST IN SILICONES

lection consists of several hundred issues of 94 Chinese aeronautical periodicals, most of which began publication about 1930.

I.A.S. Newslines

▶ Link Consultant . . . Link Aviation, Inc., announced that it has retained the services of **Luis de Florez,** Fellow, an internationally known engineer and synthetic trainer authority, as consulting engineer.

▶ **Major Raymond R. Hajek,** Associate Fellow, is Chief of Requirements and Development Division, Director of Operations, Military Air Transport Service, Andrews Field, Md.

▶ Joins Martin . . . **Paul E. Hovgaard,** a Fellow, formerly General Manager for Piasecki Helicopter Corporation, is now Project Engineer for all current flying boat projects of The Glenn L. Martin Company.

▶ Technical Adviser . . . Appointment of **Jerome Lederer** as Technical Adviser to the United States Aviation Underwriters, Inc., has been announced. An I.A.S. Fellow, Mr. Lederer will continue as Director of Flight Safety Foundation, nonprofit organization organized in 1947 to promote safety in aviation.

▶ Special Mission . . . **Col. Charles A. Lindbergh,** a Fellow, has been in Germany on a special mission inspecting the Berlin airlift and serving as a special adviser on technical matters to Air Force Chief of Staff Major Gen. Robert W. Douglass, Jr.

▶ Designer and Scientist Honored . . . **Dr. Hans J. Reissner,** one of the great aviation pioneers, an Associate Fellow, who designed the first all-metal plane to fly in 1912 and the first controllable-pitch props in World War I, was honored January 18 on his 75th birthday by leading scientists in applied mechanics and aeronautical engineering at a dinner in New York City. A *Reissner Anniversary Volume,* containing 32 contributions by leading authorities in U.S., U.K., France, Germany, Sweden, Norway, and Yugoslavia, was presented at the dinner. Dr. Reissner is Professor of Aerodynamics and Aerostructures at Brooklyn Polytech.

▶ Civil Aircraft Study . . . New statistical study of the 97,619 civil aircraft registered with the C.A.A. on August 1, 1948, was announced by **Del W. Rentzel,** Administrator of Civil Aeronautics and I.A.S. Honorary Member. Study reveals that, in spite of all eliminations, number of civil planes increased 4,975 from the 92,644 contained in 1947 report.

▶ Special Executive Trainee . . . **Harold W. Thomas,** Associate Fellow, an Engineering Test Pilot at Lockheed Aircraft, has been appointed by Hall L. Hibbard to the 2-year Special Executive Training Program involving all phases of the company's operation. For the past 4 years he has been engaged in engineering test flying at Lockheed and prior to this was Chief Experimental Test Pilot for Curtiss-Wright Corporation, Buffalo plants, Airplane Division.

▶ With Radioplane Company . . . **O. L. Woodson,** described in the December REVIEW as having joined the Radiophone Company as Project Engineer, actually is with Radioplane Company, Van Nuys, Calif., where he is Director of Research. Mr. Woodson is an Associate Fellow.

▶ Named Robinson Director . . . **T. P. Wright,** Honorary Fellow and Vice-President in Charge of Research, Cornell University, has been named to board of directors of N.Y. feederline, Robinson Airlines, with headquarters in Ithaca. Mr. Wright also was appointed full member of N.A.C.A. by President Truman, having served out the unexpired term of the late Orville Wright. He will serve on board until December 1, 1953.

Corporate Member News

• Aluminum Demand Ahead of Supply . . . Continuing strong demand for aluminum and its products, plus combination of conditions that prevented adequate increases in production and provoked tight supply-and-demand situation last year, probably will continue to exist for the early part of this year as well, according to President Roy A. Hunt of **Aluminum Company of America.**

• Nonfatality Record . . . On December 31, **American Airlines** completed 3,933,000,000 passenger-miles without a passenger fatality since March 3, 1946. Safe passenger-miles flown since then exceed total passenger-miles flown in American's previous 20 years in air transport business . . . American has closed its flight stewardess school at Ardmore, Okla., and has opened a more completely equipped one at its Chicago Municipal Airport hangar. New school includes mock-up of DC-6 cabin and dormitories on 3rd floor of hangar for trainees.

• Bonanza Holds Long Distance Record . . . Nonstop flight of 2,400 miles from

BEECHCRAFT MENTOR

First flight photo of new Beechcraft Model 45 Mentor. Specially designed as a primary and basic-advanced trainer, the Mentor is an all-metal, two-place single-engined type of high performance combined with low fuel consumption and high operating economy. Engineering estimates place maximum dive speed at 280 m.p.h. Beech claims it is built to provide an ultimate load factor of 10 for maneuvers.

Honolulu to Oakland, Calif., by Capt. Bill Odom in a Bonanza gives to **Beech Aircraft Corporation** and the U.S. undisputable possession of new world record in long-distance flying for planes in its category. This attempt is not expected to be the last by Captain Odom, Beech says, which also stated that Odom had sufficient fuel for more than 1,500 miles of additional flight in still air when he terminated the attempt to reach Newark, N.J., with complete approval of Beech management.

• Bendix 'Cans' Dynamotors . . . Using an ordinary tin can and sea-level air, **Bendix Aviation Corporation** engineers have designed a dynamotor that always operates under sea-level conditions and sea-level efficiency, even though it may be 100,000 or more ft. in the air. Unit is hermetically sealed in ordinary No. 2 can commonly used in canning vegetables.

• Boeing Leading Air Force Air-Frame Builder . . . Foremost builder of air-frames for the Air Force from the standpoint of weight, as well as dollar value, **Boeing Airplane Company** is getting contracts for 11,224,600 lbs. or 34.3 per cent of total, more than one-third of Air Force total . . . C-97 production was upped from 27 to 50 by Air Force, bringing to 108 total number C-97's and Stratocruisers now on order. New Stratofreighter will be C-97A type, powered by 3,500-hp. Pratt & Whitney Wasp Major engines and containing some advances in design resulting in B-50 development . . . Small Boeing 502 gas turbine is envisioned for use in land vehicles. Weighing about 1,150 lbs., it produces around 200 hp. Although certain advantages are evident, there are serious drawbacks acknowledged by Boeing engineers, such as tremendous air consumption, high fuel burning when idling, and compressor inlet noise, which so far have defied solution.

• Brown Instruments School 1949 Program . . . Industrial maintenance and repair courses conducted for the past 15 years by **Brown Instruments Division** of Minneapolis-Honeywell Regulator Company will be divided during first 6 months of 1949 into four classes of 5 weeks each, with longer courses for company personnel. The 5-week classes will continue through June 17.

• Convair Revises Plans . . . Cancellation of subcontract work has freed some $300,000,000 which will be utilized for substantial additional numbers of B-36 bombers and extensive modernization and improvement of the other B-36's and B-50's now on contract to **Consolidated Vultee Aircraft Corporation.**

• Continental Motor's Army Order . . . An initial $18,800,000 order from the Ordnance Department of the Army for a new type air-cooled tank engine has been awarded **Continental Motors Corporation,** together with authorization for facilities and special tooling needed to produce the order. Contract will be handled in Continental's Muskegon plant and in a large Government-owned factory there. It is providing jobs for about 1,500 persons. Engine being produced is twelve-cylinder V-type built to use 80-octane gasoline and rated at 810 hp. without supercharger and 1,040 hp. with.

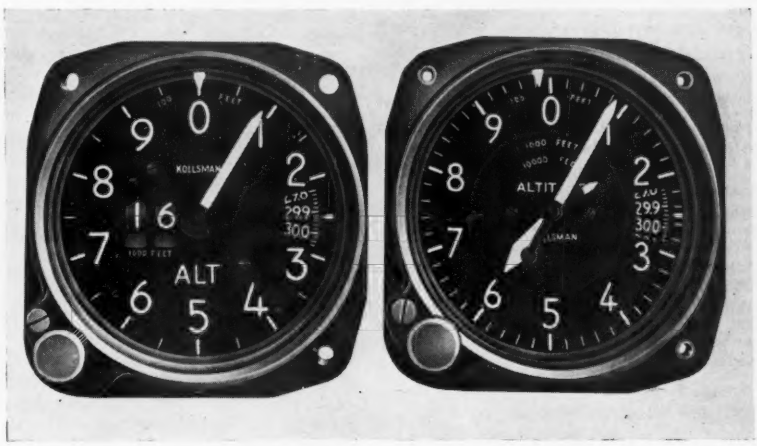
• Stratojet Subcontract to C-W . . . **Curtiss-Wright Airplane Division** received a subcontract totaling $1,353,424 to build ailerons and flaps for the B-47 Stratojet bomber for Boeing-Wichita.

• Douglas Navy Orders . . With orders for 28 F3D jet fighters and 356 planes of AD Skyraider series, **Douglas Aircraft Company, Inc.,** is second highest Navy contractor.

• Still in Float Business . . . Rumors that **Edo Corporation** was "virtually out of the business of making seaplane floats" were flatly denied by Earl D. Osborn, founder and President of the Long Island company. Said Osborn, "We have been in the float business for 23 years and intend to remain in it." Edo, which has been concentrating on important Army, Navy, and Air Force contracts, had consolidated its float sales division into general sales department, apparently giving rise to the erroneous reports. Production was resumed last December of Model 2000 floats for use on the Aeronca Sedan and last January on Model 3430 floats for Cessna 195.

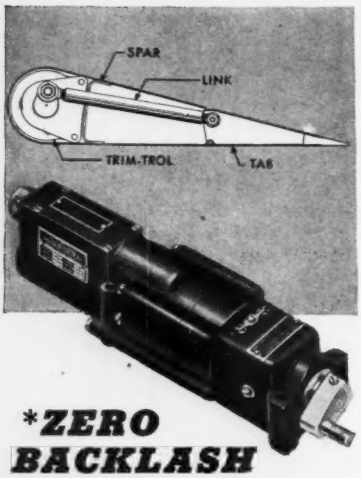
• G-E Building Search Radar for Airports . . . New radar device permitting planes to make all-weather approaches and landings in greater safety and with fewer delays has been developed by **General Electric Company.** Civil Aeronautics Administration has awarded company $2,840,427 contract for 27 units, 22 of them going to air control towers in this country, one to Hawaii, and four to Alaska. Installations begin early next year... World's largest supersonic wind tunnel unveiled at Lewis Flight Propulsion Laboratory by NACA contains G-E drive, including motors, controls, and switchgear.

• Leading Navy Air-frame Builder . . . **Grumman Aircraft Engineering Corpora-**



NEW KOLLSMAN ALTIMETER SPEEDS ALTITUDE READING

Just designed and developed by Kollsman Instrument Div., Square D Co., the Kollsman 160 Altimeter is a new sensitive instrument with a 2-digit altitude-counter in the dial and a single pointer (left) instead of three pointers in the conventional model (right). "The 2-digit counter in the new instrument both speeds up and simplifies the reading of altitude," said Victor E. Carbonara, Vice-President of Square D Co. and General Manager of Kollsman Instrument Div., announcing the Kollsman 160 Altimeter. Mr. Carbonara, an Associate Fellow of the Institute, added that the new instrument will substantially relieve the pilot of the hazards of error and confusion in reading correct flight altitude, particularly at times of stress.



*ZERO BACKLASH and SIMPLICITY of the

Trim Trol

Trim Tab Actuator

...resulted in its adoption in the flight control systems of the following advanced aircraft:

GRUMMAN "ALBATROSS"
JR2F-1, SA-16

McDONNELL "BANSHEE"
F2H-1, F2H-2

CHASE "AVITRUC"
YC-122, YC-123

CHANCE VOUGHT

REPUBLIC

Improvements in '49 models have been incorporated as a result of continuous development:

* ZERO BACKLASH at the output shaft thru Balanced Torque drive • Radio Noise Filter built in to meet the noise level requirements of Specification AN-M-10a • Reduced weight • Increased Performance • Increased Brush Life • Infinitely adjustable limit switches and position transmitter accessible AFTER INSTALLATION • "Positioning" and synchronizing controls available without modification of envelope • Two basic models to suit space requirements.

WRITE TODAY FOR LITERATURE ON THESE NEW '49 MODELS

AIRBORNE

ACCESSORIES CORPORATION

25 MONTGOMERY STREET
HILLSIDE 5, NEW JERSEY

Western Representative

JAMES L. ADAMS & CO.
LOS ANGELES 6

tion, with 26 per cent of total air-frame dollar value, is leading Navy air-frame builder so far in fiscal 1949. Navy had allocated $553,635,000 for plane procurement at press time, Grumman receiving orders for 317 F9F jet shipboard fighters, 23 AF-1 carrier attack planes, and 6 JR2F Albatross light utility transports.

• Tests Turn Altitude Chamber into Fruit Stand . . . **Lockheed Aircraft Corporation's** giant altitude chamber was converted into a fruit stand not long ago to carry out extensive tests on 34 varieties of perishable fruits and vegetables. Project, carried out jointly between Lockheed and Department of Agriculture, was initiated to answer question: Will lettuce wilt and tomatoes burst during rapid climbs and ascents in aircraft? Result: Close inspection of "air-borne" fruits and vegetables by experts failed to find any effects of altitude changes; they remained the same as fruits and vegetables under normal store conditions.

• Honeywell Gets Air Force Order . . . A $1,000,000 contract calling for manufacture of new type electronic controller for use on reactivated B-29's has been given **Minneapolis-Honeywell Regulator Company** by the Air Force. Controllers will modernize the turbosupercharger control systems on the bombers.

• $18,000,000 Payroll Loss Due to Cancellation . . . Readjustments in Air Force procurement program to remain within budgetary limitations resulted in immediate layoff of about 1,900 employees at **North American Aviation, Inc.,** Long Beach plant, and about 700 at its Los Angeles plant. Termination of contracts represents payroll loss of approximately $18,000,000 at North American.

• Northrop Unaffected by Cancellations . . . Officials of **Northrop Aircraft, Inc.,** believe Air Force cancellation of two of company's contracts is unlikely to have any major effect on plant operations at Hawthorne where about 6,000 persons are employed. Canceled contracts covered production of 30 RB-49 Flying Wings and 30 C-125 three-engined Raiders. Nearly all production of RB-49's had been subcontracted to Convair (Ft. Worth). Northrop's Hawthorne plant is now in production on initial contract for 23 Raiders which was not cut back, in addition to work on experimental contracts on XF-89, X-4, and a number of military contracts company cannot make public.

• Total of 673,582 passengers was carried by **Pan American World Airways'** Latin American Division in 1948, completing 557,659,702 passenger-miles, in addition to 28,471,422 lbs. cargo. Division also completed 3½ years in which almost 2,000,000,000-passenger-miles were flown without a fatality to passengers or crew . . . On the Atlantic run, 56,000 passengers were carried aboard Clippers of Pan Am during 1948. Westbound traffic continued to lead eastbound with about 33,000 persons coming into the U.S. by Clipper, while some 22,700 left for Europe and beyond. Year's total was about 6,000 under 1947's 62,000. Passenger-miles flown were 301,822,000 and plane-miles 13,485,000. In addition, 31,400 passengers were carried on the Bermuda run.

• Turbo-Wasp Completes 150-Hour Test . . . The JT-6B Turbo-Wasp jet engine (Rolls-Royce Nene) successfully completed its official 150-hour military qualification test with static thrust ratings up to 5,000 lbs., **Pratt & Whitney Aircraft Division,** United Aircraft Corporation, says. First production engines are going to Grumman for installation in the F9F-2 Panther. Pratt and Whitney made extensive changes in accessory case design to meet Navy requirements. Significant advantage of engine is sparing use of strategic or scarce metals for components that must have high strength at high temperatures.

• Ryan Gets Multimillion Dollar Jet Parts Order . . . A multimillion dollar volume production order for exhaust cones, burner assemblies, combustion chambers and other specialized jet engine parts was given to Metal Products Division of **Ryan Aeronautical Company** by General Electric for their J-47 (TG-190) model now going into mass production. Program will be a major factor in work of Metal Products Division for several years, officials say. Several hundred additional workers have been hired for the program, and more may be required in 1950. First deliveries will be made early this year.

• Speed Nut Development . . . New development in Speed Nut which will create tremendous savings in all operations requiring the fastening of square nuts to sheet metal panels, was announced by **Tinnerman Products, Inc.** Called the Speed Grip Nut Retainer, new product will make big assembly savings by eliminating welding, clinching, or staking, company says. New nuts are easily snapped into place by hand or with screw driver, and their spring steel "mechanical hands" hold nut in bolt-receiving position.

• U.A.L. Courtesy Card . . . New procedure for assuring parties of two obtaining seats together is being carried out by **United Air Lines.** Ticketing agent issues a small courtesy card which is presented to stewardess on boarding plane. Stewardess honors card, showing the two passengers to a pair of previously blocked-off seats . . . Holiday travel by air last Christmas helped United fly almost 30 per cent more in December, 1948, than in previous December. Air mail and freight also showed substantial increases. During December, company flew estimated 93,646,500 revenue passenger-miles, increase of 28.5 per cent over December, 1947, and 6½ per cent from November, 1948. Air-ton-miles were an estimated 57½ more than a year ago December and up 54 from November. Freight-ton-miles were up 59 per cent from December, 1947, but off 2 per cent from November, 1948.

• Westinghouse Year-End Statement . . . For first 11 months of 1948, **Westinghouse Electric Corporation** produced and shipped $873,342,638 worth of electrical equipment and household appliances, 6.5 per cent above full year of 1947 and new high record for any similar period in company's history. New orders during the 11 months totaled $960,556,927, compared with $898,333,791, in same period last year.

Meet Your Section Chairman

Carroll J. Peirce

Columbus Section

A native of New Orleans, Carroll J. Peirce several years ago had a personal interest in the fortunes of the Goodyear F2G airplane taking part in the air races at Cleveland, and when it won he felt the satisfaction of having contributed to its victory, having done some of the engineering for the plane.

Mr. Peirce, who is 38, first became interested in aerodynamics through performance of advanced fluid mechanics calculations in connection with civil engineering work he was doing in 1940. At present he is Director of the School of Aviation and Professor of Aeronautical Engineering, Ohio State University, where he is in charge of University Airport, Don Scott Field. Besides teaching graduate courses in supersonic aerodynamics and exterior ballistics, he coordinates and promotes aeronautical research activities in various departments of the University. He has been at Ohio State since March, 1947.

▸ **Wide Professional Experience**—Mr. Peirce, who was graduated from Tulane University in 1931 with a degree of Bachelor of Engineering in Mechanical-Electrical Engineering and received his doctorate of Science in Aerodynamics at University of Michigan in June, 1942, has a wide professional experience as a civil and aeronautical engineer.

Beginning in New Orleans, where he was engaged in the design of concrete and steel structures, hydraulic machinery, and preparation of estimates and specifications as Designing Engineer with the Sewerage and Water Board between 1933–1940, Mr. Peirce became a graduate student in aeronautical engineering at Michigan in September, 1940, and a Teaching Fellow in Engineering Mechanics in February, 1941. From the following February to June, 1942, he also was an Instructor in Aeronautical Engineering.

▸ **Joins Goodyear**—In that month he was appointed Manager of Structures, Goodyear Aircraft Corporation, Akron. There he was in charge of all stress analysis and static tests on airplanes and airships being designed by the company.

A year later he was named Manager of Structures and Aerodynamics, in charge of stress analysis, weight control, static tests, aerodynamics, and engineering flight test and was responsible for all technical procedures used by those departments.

During this period of his employment, Goodyear designed and built a new nonrigid airship, the M type, for the Navy, in addition to the F2G Navy fighter powered by a Pratt & Whitney 3,000-hp. engine. In the latter program, a total of four complete wings and three tail surfaces were designed, with all engineering reports being prepared for other companies for whom Goodyear was acting as subcontractor. Some 90 persons, including four company consultants, four engineering test pilots, stress analysts, aerodynamicists, and flight engineers were under Mr. Peirce's direction. Several proposals for jet-propelled aircraft were prepared and submitted to the Army Air Forces and Navy.

In February, 1946, Boeing Airplane Company (Wichita) made Mr. Peirce its Chief of Aerodynamics, where he is to date in charge of wind-tunnel programs on a transport aircraft, an Army liaison airplane, and several experimental models for testing new types of control systems. Wind-tunnel testing was carried on in five tunnels.

▸ **Technical Publications**—Among the technical papers by Mr. Peirce which have been published are "Pile Driving Formula," and "Boundary Layer Control" in the *Journal of the Louisiana Engineering Society* in 1933 and 1940, respectively. "Airplane Stability" (summary) appeared in the December, 1946, number of the *S.A.E. Journal.*

In addition, Mr. Peirce, who helped to form the Akron Section of the Institute, delivered papers before that local organization and before the Wichita Section of the S.A.E. on the subjects of "High Speed Aerodynamics" and "Airplane Stability," respectively.

In 1946, he was married to Mary Koss, of Akron, and they have a son, Stephen.

I.A.S. Sections

Baltimore Section

Don K. Covington, Jr., *Secretary*

At the Section's December 8 meeting, attended by 100 members, Dr. Hugh L. Dryden, Director, Aeronautical Research, N.A.C.A., spoke on "Sixty Years of Supersonic Research." Chairman O. J. Schaefer presided.

▸ **From Early Beginnings**—Dr. Dryden unfolded the story of supersonic research from its early beginnings in the research of Salcher and Ernst Mach up to the present extensive wind-tunnel program.

Following the lecture, a general discussion took place in which general policies of the Government agencies relative to supersonic research and status, as limited by security regulations, were talked over by the members and Dr. Dryden.

Columbus Section

Ferdinand L. Jesse, *Secretary*

The December 15 meeting featured Dr. E. H. Gamble, Head, Research Engineering, Curtiss-Wright Corporation, on "The Role of Electronics in the Aircraft Industry." C. J. Peirce, Chairman, presided with 35 members present.

▸ **Can't Get All Answers**—Dr. Gamble stated that, while electronics cannot replace the thoughtful efforts of aircraft designers or reduce all airplane designs to the mere feeding of data into an electronic computer with the answers automatically appearing in a few moments, the use of servomechanisms in aircraft and the proper application of electronic simulators to research can facilitate the solution of many problems.

Electronic simulators and computers are possible because electronic circuits can be devised which exactly duplicate, or closely approximate, the actions and reactions occurring in nature. For instance, the response of a thermal system or a mechanical system can be duplicated in effect by an electrical circuit.

▸ **Dehmel Trainer Example**—An excellent example of an electronic simulator is the Dehmel Trainer, which is a complete reproduction of a Boeing Stratocruiser control room and which is used to give pilots actual flying experience without taking off from the ground (AERONAUTICAL ENGINEERING REVIEW, p 7, July, 1948).

Other electronic simulators are now being used to develop control systems

(*Continued on page 83*)

Honorary American Fellow for 1948
Clark B. Millikan, Acting Director, Guggenheim Aeronautical Laboratory, California Institute of Technology

Editorial

Honors List

Honors Night for 1949 has come and gone. Now a traditional event on the American aeronautical scene, this year it lived up to every expectation of those who started it many years ago.

The Institute has never been in a position to offer large tangible rewards to those it honors. True, there are modest honoraria attached to several of our annual awards, but they are nominal in amount and were intended by their donors chiefly to underwrite the expenses that might be incurred by the recipients in coming to the Honors Night Dinner. For the most part, then, all we can say to those men whose work has advanced our knowledge in the aeronautical sciences is—"Stand here for a moment and receive the acclaim of your fellows"—as we add their names to the roster of the distinguished men of aeronautics who have gone before them.

Honorary Fellowship in the Institute is the highest recognition that we can give to those who have made major contributions to the art and science of aeronautics. Each year two such men may be chosen: one from among the American Fellows and one from the list of Foreign Fellows. They are selected by secret ballot by the I.A.S. Fellowship.

The Honorary Fellows for 1948 need no introduction to Institute members. They are men who have given unstintingly of themselves and their talents to advance the art, each in his own field. We welcome to the distinguished company of the elect Dr. Clark B. Millikan, of the Guggenheim Aeronautical Laboratories of the California Institute of Technology, and Capt. J. Laurence Pritchard, Secretary of Britain's Royal Aeronautical Society.

Fellowship in the Institute is in itself a high honor. In the 17 years of the Institute's existence and out of a total membership that is now in excess of 7,000, there are but 172 Americans who have attained that distinction. It is the hallmark of success in a man's chosen profession to be able to write F.I.A.S. with his name.

Fellowship in the Institute is not easily attained. A maximum of ten new American Fellows may be elected each year—and some years the number who acquire the necessary number of votes is less (there were but 9 Fellows elected this year). The Fellows themselves elect new Fellows. Balloting is strictly secret, and a favorable vote of three-fourths of those voting is necessary to elect. Only Associate Fellows of 1 year's standing are eligible.

This last is important. Our Secretary has been asked many times why this or that individual of obvious qualification is not a Fellow. Nine times out of ten it is discovered that he is not an Associate Fellow, although he may have been a member of long standing. The point to remember is that advancement from Technical Member to Member and from Member to Associate Fellow *is not automatic*. Every I.A.S. member must file application for advancement in grade, up to and including Associate Fellowship. And it is only the Associate Fellows who are eligible for election to Fellowship.

So, if you feel that you or your associates should be considered for election to I.A.S. Fellowship, be sure that all the requirements have been met. Our Membership Committee is ready and willing to regrade members upward, but they cannot act unless you act first by filing your application for regrading. A letter to the Institute Secretary will get you full information and the proper forms.

S. P. J.

The Berlin Airlift

Excerpts from the Honors Night Dinner Address of

Major Gen. Laurence S. Kuter
M.A.T.S. Commander

"DESPITE THE FACT THAT our efforts have been almost exclusively devoted to Vittles," General Kuter declared in the opening of his address to the I.A.S. at the Honors Night Dinner on January 24, "M.A.T.S. has still managed to achieve many of the objectives of its basic program" (eventual organization and integration of military air transport services into one global command for entire military establishment). "Particularly it has proved that integration in the Armed Services can and does work to the decided advantage of all concerned.

"The Russian blockade of Berlin was abruptly imposed on 21 June, 1948. . . .

"On 10 July M.A.T.S. itself was called on for its first squadron of C-54's, drawn from its regularly scheduled operations. . . .

"On 23 July, M.A.T.S. was ordered to establish an Airlift Task Force Headquarters in Europe. . . .To head this staff in direction of the airlift, M.A.T.S. chose Major Gen. William H. Tunner, its Deputy Commander for Air Transport and well known as commander of A.T.C.'s wartime supply of China over the 'Hump.' Since the departure of the first staff, M.A.T.S. has contributed to Vittles some 4,000 personnel, including the bulk of the air crews. At the same time that General Tunner took over, M.A.T.S. also furnished 8 squadrons of 72 C-54's, with three crews per aircraft.

"Currently in Germany, working the airlift, are approximately 225 C-54's, including 24 R5D's of M.A.T.S. Navy element plus an additional 75 aircraft in the maintenance pipeline. Not to be overlooked is the additional airlift provided by the heartbreaking effort of the R.A.F. fleet of some 100 planes of miscellaneous types, none designed for the job and all difficult to maintain. . . ."

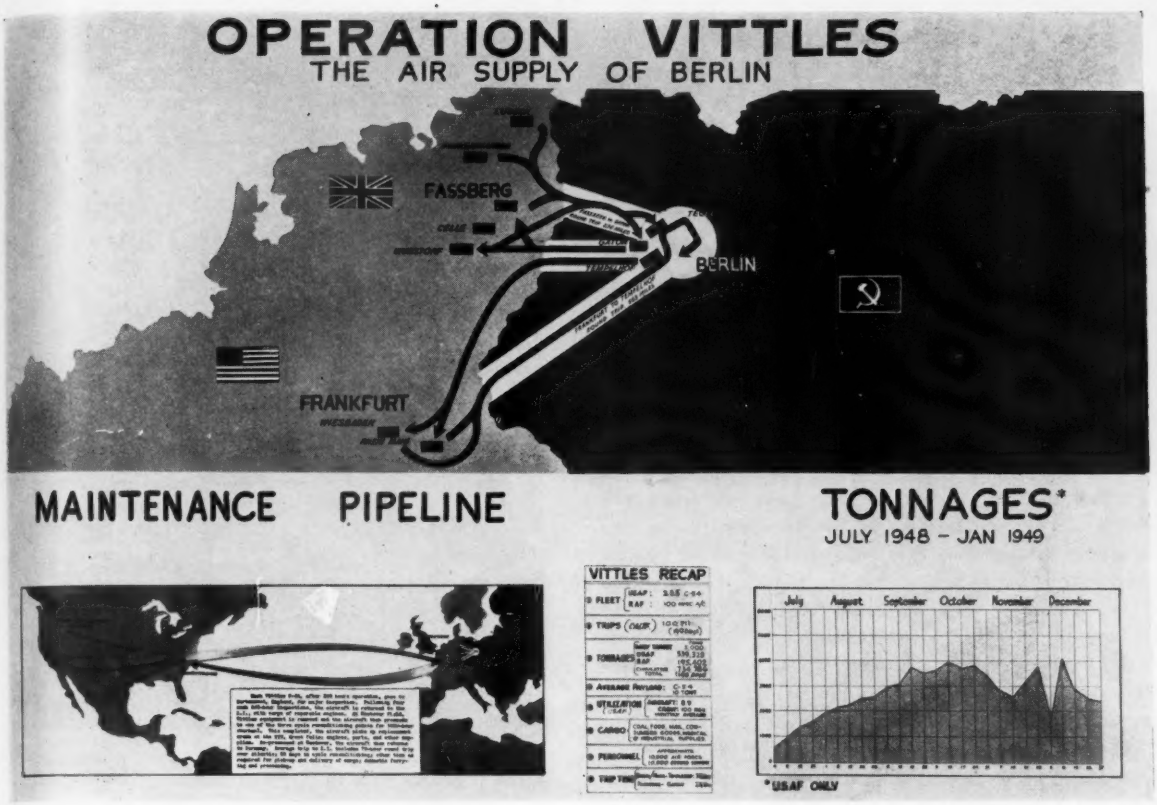
Remarkable Traffic Control

"It is clear that the news of Vittles' impressive performance lies in its remarkable traffic control, largely made possible by taking advantage of every modern aid to navigation and all-weather flying. In addition to carefully located radio ranges and beacons and air traffic control centers, GCA has made a tremendous contribution to the maintenance of continuous operations. GCA in Vittles is working about five times as rapidly as it has ever done before, and it is not uncommon to stand in the GCA truck and see five aircraft on the scope, brought in surely and safely, one after the other by the expert teams who man these units. . . .

"Robert V. Garret, air safety inspector for the Civil Aeronautics Board, declared Operation Vittles 'has advanced the art of traffic control 10 years.' Representing the C.A.B., Garret inspected all phases of the airlift operation, concluding that the concept of traffic control (as used in Vittles) could easily be applied to New York, Washington, or Chicago immediately without adversely affecting the slow aircraft.

"Needless to say, the finest communications facilities in the world would mean little without high caliber, experienced pilots—men who can *use* these aids and who can maintain on every trip exact speeds, altitudes, and position. This is precision flying at its best—and it must be just that, with a constant procession of C-54's flying the corridors 3 min. apart, in all hours and all weathers. On one occasion, 18 September, planes were landing at Berlin at intervals of 48 sec., and this on a day when 18 of the 24 hours were instrument conditions. . . .

"It is also interesting and significant, I think, to note that for the past 10 days tonnage totals in Vittles have stayed at an almost constant daily average. In other words, although the airlift is operating continuously through the good and bad days of a German winter, there is no relation between weather and tonnage."



Maintenance Urgent and Difficult

"With Vittles aircraft in maximum use, producing an average utilization of some 8 hours per day per plane, the entire problem of maintenance has at all times been both urgent and difficult. In general, this is the maintenance pattern we follow:

"After flying 200 hours, a Vittles C-54 receives its 200-hour check in Germany or England. After four 200-hour tours and four such checks, the aircraft is returned to the U.S. by a ferry crew. In the plane is a cargo of repairable equipment.

"Upon arriving in the U.S., the plane is sent to one of three cycle reconditioning plants operated for the Air Force by civilian contractors. Here the plane is given a complete 1,000-hour check and here special installations and tank sealant work are accomplished. All told, this is a processing that takes approximately 44 days. Once reconditioned, the plane picks up a cargo of parts, engines, and replacement crews and returns to duty in Germany. It is this continuous maintenance pipeline that M.A.T.S. must keep filled to ensure at all times a full operational fleet of 225 aircraft at work in Germany. . . .

"When it became clear that the duration of Vittles was indefinite, M.A.T.S. laid immediate plans for the rotation and replacement of the crews. With this in mind, M.A.T.S. established at Great Falls, Mont., one of its principal bases, an R.T.U. or Replacement Training Unit, where we are training replacement crews at the rate of 122 per month, including 18 Navy crews. . . . First pilot qualifications have been set at 1,500 hours, including 100 C-54 hours and 75 hours each of night and instrument time. Flight and route checks, plus written examinations, complete the requirements. The entire 3-week course at Great Falls is geared to provide full refresher training, under conditions resembling as closely as possible those the crews will encounter in Germany."

Record of Results

"To date, in approximately 6 months of operation, the Combined Airlift Task Force has delivered to Berlin more than 700,000 tons of cargo, over 73 per cent of which flew in U.S. aircraft. Total trips to Berlin have now well passed the 100,000th mark. With an augmented fleet and considerably improved weather, recovery from the low tonnages of November and early December has been excellent. For example, the 7-day period from 31 December to 6 January produced a total tonnage of 35,379, for a daily average of over 5,000 tons. This was the highest sustained daily performance to date. . . .

"For the first time in peacetime history, air transport—strategic air transport—has become a conspicuous expression of American air power and peace power and an effective weapon of diplomacy. . . .

"The future of strategic airlift lies in the development and production of the proper transport aircraft, a big

(*Continued on page 41*)

Dr. Reichelderfer*

on

"What Aeronautical Scientists Are Doing About the Weather"

An Abstract of the Luncheon Address at I.A.S. Annual Meeting, January 25.

IN THE LAST 5 YEARS there have been more research and development aimed at doing away with the unbenevolent features of the weather than in all history theretofore. Although that statement is not susceptible either to proof or disproof, it is probably true even if we include the primeval oracles, medicine men, and rainmakers on the side of history, for they would be more than counterbalanced by the heroic efforts at rainmaking and hurricane control during the last few years.

The attack on weather has been three-pronged—first, the design and development of all-weather flying equipment and other mechanical means for going ahead with plans and operations in more or less complete disregard of weather, come rain or shine, cold, heat, or high water. The aeronautical sciences have made marvelous progress in this direction. Pressurized aircraft to fly above bad weather; dependable power plants that keep going in extremes of temperature, through ice storms, heavy rain, and almost anything that the atmosphere has to give; and many navigational aids in blind landing installations that permit taking off and landing in fog and blinding rain or snow are among the phenomenal developments. There are many other examples of progress in the aim to "ignore" the weather, and most certainly this is the best ultimate solution, although there may remain a few exceptions that cannot be wholly transcended after all practical countermeasures have been developed. The occasional destructive tornado and the "cloudburst" form of thunderstorm are examples of such exceptions.

The second arm of attack against the weather problem has been through the science of meteorology and the development of the services of weather reporting and forecasting. There has been noteworthy progress in this sector also, but it has not been so spectacular as the progress in aerodynamics, aeronautical engineering, and air navigation. The past 5 years have brought rawinsondes for measuring winds above the clouds, radar for detection and tracking of severe thunderstorms and hurricanes, arctic weather stations, ocean weather ships and aircraft reconnaissance to close some of the previous gaps in our weather reporting organization, and research studies in severe thunderstorm formations and in development of electronic means for computing weather predictions in the hope of eliminating the inexact factors in present methods of weather forecasting. Although the road is long and difficult before success can be reached in the plan to derive forecasts by mathematical or electronic process, there is good reason to expect more rapid progress in other branches of meteorology and weather forecasting services during the next 5 or 10 years. The large increase in the number of well-trained meteorologists and the growing breadth of meteorological research give promise of future results. It is only necessary to compare the program of scientific papers presented here this week with those representative of similar programs a decade or two ago to see how work in this field has been accelerated and strengthened. The scientific papers of the American Meteorological Society this week are so numerous that sessions will continue twice daily through Friday. A number of instances are given illustrating the enormous amount of work now going into meteorological research and development and some of the results that have been accomplished.

The third line of attack on meteorological problems has been the effort to "abolish" the weather, or at least to control its unfavorable manifestations. Members and guests who attended the symposium on cloud physics heard something about the experiments in artificial methods for precipitating rain, dispelling clouds and fog, and other forms of weather control. These methods are still in the experimental stage, and

(*Continued on page 91*)

* F. W. Reichelderfer, Chief, U.S. Weather Bureau.

I.A.S. Seventeenth Annual Meeting

Technical Sessions

Part I*

DR. ALEXANDER KLEMIN†
Aeronautical Consultant

THE AERODYNAMIC SESSIONS of this year's Annual Meeting were not so dramatic as in some preceding years. But how can such sessions always remain at the highest pitch? Airplane designers have broken through the sonic barrier, and aerodynamicists now understand far better compressibility effects and supersonics. One cannot expect every year a startling announcement of the kind that von Kármán used to make, that the drag coefficient would actually drop in supersonic flight, or that camber contributes nothing to lift at the highest speeds. This intellectual calm is only temporary. Rocket flight at a hundred miles altitude where molecules become individuals will bring fine new problems. So will the design of artificial satellites. But for the time being, research men and engineers must present papers that dig deep but do not strike out into new territory. Also, it is barely possible that another reason for the less exciting character of the aerodynamic papers, the word "restricted." For example, in one session it appeared that the fuel consumption of a jet-propelled helicopter is still restricted information. To mark things "restricted" or "confidential" can become a tiresome habit.

However, there was no lack of the striking in other directions. What, for example, could be more intriguing than a session entitled Human Engineering in Aviation? Aeronautics is not *all* a matter of physics, mathematics, design, and innumerable gadgets. It is more than fitting that psychologists, teachers, physicians should play their part and make the life of the pilot an easier one. Of course, the engineers do occasionally develop "gadgets" that help the pilot, as witness the remarkable Sperry Zero Reader (discussed in the Instruments Session), and Air-Borne Radar (Air Transport Session) that seems to be coming into its own.

To say that the Meeting was well conducted and the gathering representative is commonplace. To say that it was friendly is also true. Technicians and scientists like one another and care more for the good opinion of their fellows than for anything else in the masculine world. But there is one group within the Institute which is unique. The helicopter people still have the romance and camaraderie of early pioneers in their

souls. They responded to the inimitable charm of Igor Sikorsky and were thrilled to learn that it really took him 40 years to achieve the helicopter. Moving pictures and papers proved to them that the principle of the jet triumphant in the airplane would serve equally well in rotating wing aircraft. And they heard with pleasure a restatement of the possibilities of convertible aircraft and assurance that convertible aircraft, combining the best features of the helicopter and the airplane, will come.

There was another session besides Human Engineering whose name had claim to novelty in its title, Flight Propulsion. The power-plant people discussed compressors, blades, materials to withstand hot gases, propellants for rockets and said not a word about reciprocating engines.

One could find romance also in the sessions held jointly with the American Meteorological Society. Efforts at rain making have ceased, a sad admission that we cannot master Nature and that it would be better simply to improve forecasting. But we can now use rockets and meteors for research study of flight at Mach Numbers of the order of 100 and chart the properties of the atmosphere up to 120 km. as a prelude to the superaviation that is just around the corner.

If this review of the first 2 days started on a note of disappointment, the disappointment vanishes and

* This covers the first 2 days of the Technical Sessions.
† Helicopter Editor, *Aero Digest*, and Editor, *Handbook of Aeronautical Engineering*.

Rotating Wing Aircraft Panel: *Chairman, Bartram Kelley, Chief Helicopter Engineer, Bell Aircraft Corporation; Roy E. Marquardt, President, Marquardt Aircraft Company; Charles R. Wood, Jr., Chief Helicopter Test Pilot and Manager, Helicopter Contracts, McDonnell Aircraft Corporation; R. H. Miller, Associate Professor of Aeronautical Engineering, Massachusetts Institute of Technology; and I. I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation.*

Instruments Session: *Chairman, Victor E. Carbonara, Vice-President and General Manager, Kollsman Instrument Division, Square D Company; W. A. Wildhack, Chief, Missile Instrumentation Section, Electronics Division, National Bureau of Standards; Y. T. Li, Research Associate in Aeronautical Engineering, Massachusetts Institute of Technology; and C. F. Fragola, Engineering Section Head for Electronic Development, Sperry Gyroscope Company.*

the meeting appears as rewarding as ever when we forget aerodynamics and think of the sessions as a whole.

Besides, there were the excitements of the Honors Dinner, which always shows where aviation is going. George W. Brady received The Sylvanus Albert Reed Award "for contributions to the development of the reversing propeller resulting in shorter landing runs for large aircraft," and we see smaller airports and more frequent landings as possible at any airport in the near future. The youthful Allen E. Puckett earned The Lawrence Sperry Award for "outstanding contributions to the design and development of supersonic wind tunnels," and we know that section characteristics of supersonic airfoils will soon be accurately measured. When Dr. W. Randolph Lovelace, II, accepted The John Jeffries Award "for outstanding contributions to the advancement of aeronautics through medical research," there was another proof that the human element in aeronautics is no longer neglected. Last, but not least, what could be more encouraging than the story of "The Berlin Airlift" as told by Major Gen. Laurence S. Kuter? His speech ranged from an outline of the technical perfection of its maintenance system to anecdotes of pilots who operated 225 airplanes in the narrow corridor for an average of 8 hours a day each. At one point General Kuter quoted Robert V. Garret, air safety inspector of the Civil Aeronautics Board, as saying: "Operation Vittles has advanced the art of traffic control by 10 years." The General attributed much of the success of the lift to use of GCA (Ground Controlled Approach). Virtually all flights were "talked in," as expert crews watched the planes on radar screens.

After this speech, people felt that there was nothing in the realm of transportation which the airplane could not do.

And so with a preamble, which like many preambles may be useless, we plunge in *medias res*.

Rotating Wing Aircraft

There were four excellent papers in this session; the moving pictures were exciting, the enthusiasm of the engineers sincere. It seems clear that jet propulsion will be as useful in the helicopter as in fixed-wing aircraft. The only question is: Will it be ram-jet or pulse-jet?

The men who planned the Rotating Wing Aircraft Session did well to place together two papers on jet-propelled helicopters, one by Charles R. Wood, Jr. (McDonnell Aircraft Corporation), on "The McDonnell Ram-Jet Helicopter," advocating the ram-jet; the other by Roy E. Marquardt (Marquardt Aircraft Company), on the "Preliminary Development of a Jet-Propelled Helicopter," favoring the pulse-jet engine as the source of power.

Whether one or the other power plant is employed, the following advantages may be claimed for both:

(1) No reaction torque transmitted to the fuselage and no tail rotor, with corresponding weight- and power-saving.

(2) No supplementary engine, transmission, or complex gear box, clutch, or free wheeling.

(3) Useful load increased for short periods of operation.

(4) Initial cost of helicopter reduced and economy for short-haul transportation increased.

In the earliest stages of the undertaking, the McDonnell engineers discovered that, at a rotor tip speed somewhat below the speed of sound, ram or centrifugal force would provide enough compression for operation. For both ram-jet and pulse-jet the following factors work against efficiency:

(1) Loss of ram pressure due to inlet and inlet diffuser losses.

(2) Reduction in initial combustion chamber static pressure due to finite velocity.

(3) Thermal radiation and convection losses.

(4) Nozzle losses.

(5) External drag of the body.

Besides being simpler, the ram-jet, according to Mr. Wood, seemed to have the smaller losses, and design calculations led to the following specification: 25 lbs. net thrust at tip speed of 600 ft. per sec. (400 m.p.h.); a maximum diameter of 7.15 in., an inlet diameter of 6.15 in., and a length of approximately 33 in. (The actual ram-jet used for the original flight of the ram-jet helicopter was smaller, particularly in length.) The development included whirlstand tests, up to 700 ft. per sec. tip speed of five basic ram-jet arrangements. A ram-jet with liquid gasoline injection weighed less and was otherwise superior to one with internal vaporizers.

A two-bladed see-saw rotor was chosen because of its simplicity, and a conventional aircraft starter proved adequate because the ram-jet rotor proved to be self-propelled at a fairly low speed.

Here are the main characteristics of the McDonnell Jet Helicopter: The rotor assembly consists of two all-metal blades and two ram-jet propulsion units. The 16- and 18-ft. diameter blades tested were NACA 0013 airfoil section of constant chord; solid dural spar with a simple skin aft section attached by means of rivets and cycle-weld cement; solidity, 0.037 to 0.048; fairlings installed at the attachment of the ram-jet and rotor blades. The ram-jet propulsion engines consist of an outer Inconel shell, an inner liner, flame holders, fuel nozzles, and attaching fittings. It has conventional helicopter controls, with the cyclic pitch stick that provides direct tilt of the rotor hub *hung* from the rotor. A motorcycle-type throttle controls the ram-jet thrust at the outboard end of the collective pitch lever. A rudder is installed at approximately 45° in the effective down-wash area of the rotor blades; no horizontal tail surface is provided. The rotor head, including the reduction gears for the starter, is mounted in a gimbal ring arrangement so that the rotor shaft axis may be tilted in any direction. The ignition system consists of a spark coil connected to the rotor head distributor system which fires one ram-jet's spark plug at a time, needed for starting only, so that two 6-volt dry batteries are sufficient. A wobble pump is used to provide the initial gasoline fuel pressure to light the ram-jets as the rotor is started; the rotation of the blades delivers fuel from the tanks to the ram jets at the tips by centrifugal force.

The construction of the air frame is simple and conventional, and starting is easy. The machine has a weight empty of 280 lbs. and flies at a gross weight of 625 lbs. Grade of gasoline is immaterial.

Autorotation is satisfactory, but vertical descent is faster than for an ordinary rotor because of the drag of the ram-jets. Some 67 hours of full flight tests have shown forward speed of more than 50 m.p.h. and satisfactory controllability about all axes in all régimes of flight. Research is proceeding along many lines. The author hints at high fuel consumption in the following words: "Reduced fuel consumption is a major development requirement."

Not the least interesting part of the paper is in the conclusion, which Mr. Wood, engineer and test pilot, has drawn from his experience: "Tests have indicated that the endurance required for tactical flight operations such as observation, communications, wire-laying, spotting for artillery, photography, light cargo transport, carrier service, rescue operations, etc., in all weather, Arctic or Tropic, can be provided in a service-type ram-jet helicopter. The ram-jet helicopter in quantity production will have only a small part of the cost as compared to conventional helicopters. The maintenance will be substantially reduced, practically nil, and simplified flight characteristics should permit operation by personnel of only limited flight-training experience. A small ram-jet helicopter offers great possibilities as an 'aerial motorcycle'; a large ram-jet 'flying crane' will transport heavy loads for short distances, economically."

Mr. Wood gave excellent reasons for choosing the ram-jet. Roy E. Marquardt (Marquardt Aircraft Company), in his "Preliminary Development of a Jet-Propelled Helicopter," was just as convincing in his support of the pulse-jet motor. No analysis will decide whether ram-jet or pulse-jet is the better—such questions are decided by service experience—but the debate was instructive. Mr. Marquardt compared four types of helicopters analytically: ram-jet, pulse-jet, compressor-burner jet, and conventional gear drive. The M-14 helicopter shown in Fig. 1 typifies the ram-jet and pulse-jet helicopters. There is a basic difference between these two power plants. With the ram-jet, the tip speed is high, and the rotor is brought up to

FIG. 1. Sketch of M-14 helicopter.

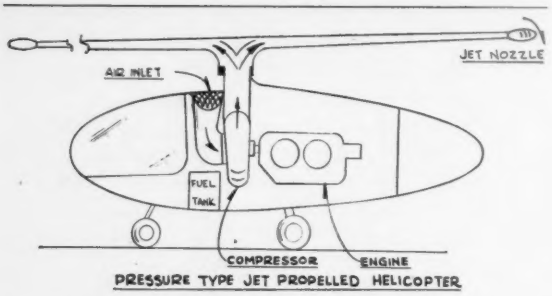


FIG. 2. Schematic drawing of compressor burner helicopter.

speed with some auxiliary power supply. With the pulse-jet, it is necessary to start the pulse-jet by some means, a compressed air supply probably, then allow the pulse-jet engine to bring the rotor up to speed. The compressor-burner jet helicopter is shown in Fig. 2. Compressed air, supplied by an engine-driven compressor in the fuselage, is carried out through the blades to burners and exhaust nozzles at the blade tips. The compressor-burner jet helicopter actually includes a whole family of machines, as the basic parameters are varied, with the most promising machine incorporating a medium-sized compressor normally operating at a fairly high compression ratio with high temperature combustion at the blade tip. The detailed analysis is currently presented in "Design Criteria for Jet-Propelled Helicopters," by C. D. Dennęy, *A.S.M.E. Transactions*, January, 1949. A summary of results is shown in Fig. 3, from which it can be seen that the ram-jet helicopter carries more pay load than the conventional gear-driven machine up to $1^1/_2$ hours duration. The compressor-burner jet helicopter carries a little less pay load than the ram-jet machine up to $^1/_2$ hour, but carries more pay load than either the ram-jet or a conventional gear drive from $^1/_2$ to $2^1/_2$ hours. The pulse-jet-driven machine carries as much pay load as the ram-jet at short endurances and equals the performance of the compressor-burner jet up to the duration where neither offers an advantage over the conventional gear drive. For 1 hour the pulse-jet helicopter carries 90 per cent more pay load than the conventional machine; for 2 hours it carries 50 per cent more pay load. Performance-wise at least, the pulse-jet helicopter appears, according to Mr. Marquardt, to be the most interesting of the types of jet power plants now being considered.

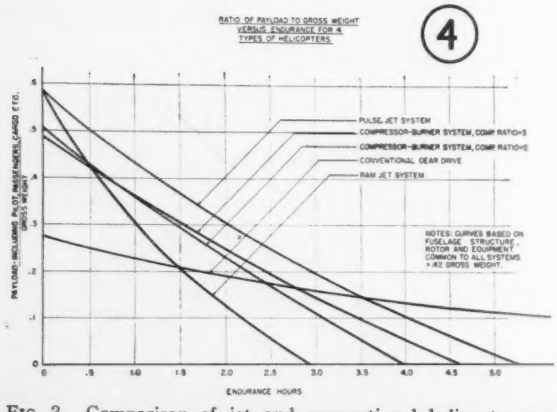

RATIO OF PAYLOAD TO GROSS WEIGHT VERSUS ENDURANCE FOR 4 TYPES OF HELICOPTERS.
4
PULSE JET SYSTEM
COMPRESSOR-BURNER SYSTEM, COMP RATIO=3
COMPRESSOR-BURNER SYSTEM, COMP RATIO=6
CONVENTIONAL GEAR DRIVE
RAM JET SYSTEM
NOTES: CURVES BASED ON FUSELAGE STRUCTURE, ROTOR AND EQUIPMENT COMMON TO ALL SYSTEMS + 42 GROSS WEIGHT.
PAYLOAD: INCLUDING PILOT, PASSENGERS, CARGO ETC. GROSS WEIGHT
ENDURANCE HOURS

FIG. 3. Comparison of jet and conventional helicopter performance.

While no analysis is better than the assumptions made, the curves of Fig. 4 are worthy of serious consideration. Also they have a qualitative rightness about them. Just as with fixed-wing aircraft, the ram-jet only comes into its own at extremely high speeds. At low and moderate speeds the pulse-jet has a better chance because it is less dependent on ram effect.

Passing over Mr. Marquardt's account of his whirling and flight tests, we signal out a number of points of general interest:

(1) For a 20-ft. rotor, it is possible to restrict length of the pulse-jet engine to 36 in.

(2) The pulse-jet engine is beset by structural difficulties, collapsing failures from high centrifugal loads, and effects of high temperatures in the tailpipe.

(3) A rudder hinged on a 45° line is effective both in hovering and in forward flight.

(4) Noise of the pulse-jet is not alarming.

(5) The engine is surprisingly low in weight.

As usual, Mr. Sikorsky gave a charming lecture, finely illustrated with slides and motion pictures. He took the liberty of mentioning two dates of personal interest: "Exactly 40 years ago, in January, 1909, I began the construction of my first helicopter.... After a year and half of hard work with helicopters, I realized that the power plants, the general level of aeronautical knowledge, and my own qualifications were, at that time, inadequate to solve the helicopter problem. Therefore, I shifted my attention to fixed-wing airplanes."... And, later on in the lecture: "Finally, exactly 10 years ago, in the beginning of 1939, the decisions were made, and we started the construction of the VS-300 helicopter." The distinguished pioneer managed at the same time to present the most significant developments of the day in rotary-wing aircraft. These are:

(1) Los Angeles Airways has accomplished wonders in load-carrying and expediting of mail delivery. The development of night-flying equipment and the modification of aircraft has made it possible for a single Sikorsky machine to carry about 7,000 lbs. per day, flying 8 hours per day, for the past several months—a rough total of 413,000 lbs. in the course of 1 year.

(2) A single main sustaining rotor still seems to be the most advantageous configuration.

(3) The jet-propelled helicopter and the high-speed convertible helicopter are in the offing.

(4) In the Sikorsky S-52 these points appear to be of general interest: "Numerous cross-country flights, totaling approximately 10,000 miles to date, have revealed most encouraging accomplishments in ease of control. A stabilized control stick, with operating characteristics similar to conventional airplanes, has been achieved by features in the basic design *without* the addition of any special power-absorbing, stabilizing

devices. There are no bungees in the control system and no irreversibility.... Because of the excellent longitudinal stability displayed, there is no necessity to reduce cruising speed in rough air."

We cannot be content indefinitely with the miracle of helicopter flight and must have stability also. Hence, the use of such devices as the Bell stabilizer bar, the Hiller control rotor, the Kaman servo control, the Coast Guard Helicopter Stabilizer, and speculation about the automatic pilot.

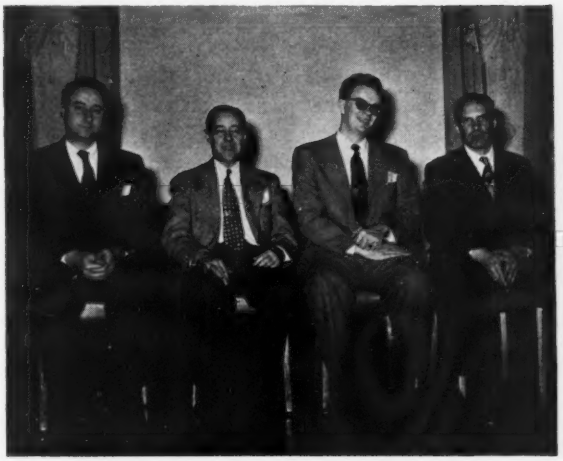
R. H. Miller (Massachusetts Institute of Technology) in "A Method for Improving the Inherent Stability and Control Characteristics of Helicopters" has done well to undertake a systematic investigation of the whole problem. He has set up the theoretical equations, employed the methods for transient response to control that servomechanism theory has given us, concentrated his attention on dual rotating helicopters and on the hovering state, and has arrived at promising though preliminary deductions and conclusions. Because the paper is of an introductory character, its full significance is not readily apparent, but the writer has already done much, and his Summary should be given in full:

"The problem of helicopter control and stability is examined with a view to establishing whether satisfactory inherent stability and control characteristics may be achieved without major design modifications and without having recourse to automatic control devices. It is shown that the possibility does exist of improving both the damping and the static stability of a hovering helicopter by a relatively minor modification of the blade mass and aerodynamic characteristics, together with the use of springs and dampers in the control system. This should result in considerably improved blind flying characteristics and a reduction in excessive control sensitivity without sacrificing maneuverability. The control characteristic of such an inherently stabilized helicopter is evaluated by means of the transient response characteristics to abrupt control manipulation."

Aircraft Design

The session on Aircraft Design dealt with modern topics: Convertible Aircraft; Present Status of Research on Boundary-Layer Control; and Measurements in Flight of Spanwise Wing Loading. The most modern, "Convertible Aircraft," came first and was discussed by R. S. Barnaby, S. M. Berkowitz, and W. H. Colcord (all of The Franklin Institute).

Convertible aircraft is at the stage where experimental construction would be better than discussion. But the more discussion, the sooner experimentation will come, and the three authors covered the situation forcefully. It would be desirable, they said, to have convertible aircraft combining the special capacities of the helicopter, with a horizontal flight speed comparable to that of an airplane of similar size and power. In such a craft, pilot and passengers should not be subjected to unusual positions, angles, or accelerations, and "conversion from direct-lift to fixed-wing flight and vice-versa must be accomplished with complete continuity of lift, stability, and control and without unusual velocities, altitudes of flight, or forces." Can this specification be met? Well, at least there are many plausible solutions, and these solutions fall into two broad classes.



Aircraft Design Speakers: *Chairman, Robert L. Hall, Assistant Chief Engineer, Grumman Aircraft Engineering Corporation; Ralph S. Barnaby, Chief, Aeronautics Section, The Franklin Institute; L. K. Loftin, Full Scale Research Division, Langley Aeronautical Laboratory, N.A.C.A.; and W. Lavern Howland, Flight Service Engineering Supervisor, Lockheed Aircraft Corporation.*

(1) *Aircraft Whose Rotor Axes Remain Substantially Vertical and Which Retain the Propeller and All the Components of a Conventional Airplane.*—In this hybrid type, the aircraft is to rise as a helicopter, reach a certain altitude, and then fly horizontally with the load gradually transferred to the fixed wing from the rotor. Finally, the rotor is to be stopped and swallowed telescopically into the hub, stowed into the fuselage, or placed in a position of minimum drag. There is comfort that propeller and fixed wing remain, assurances against ultimate disaster. The drawback lies in the duplication of elements. When rotor, hubs, drives, rotor controls, and antitorque means are superimposed on all the components of a conventional airplane, will any pay load remain?

(2) *Aircraft in Which the Rotor Axis Changes from Vertical to Horizontal in Conversion.*—There are three subclassifications of this Class 2:

(a) Use the rotor, an adjunct to a complete airplane, for direct lift. Then swing it through 90° so that it becomes a propulsive airscrew. Duplication of components is partly avoided, and there is a fixed wing as a safeguard against disaster. But the rotor designed for lift is inefficient as a propeller, and conversely a propeller makes a poor lifting rotor.

(b) Let the airplane stand on its tail, rise with the body vertical, and then swing over to horizontal flight. This type is probably the simplest "Convertible," but

the queer altitude in the vertical ascent will not be comfortable, and it is a problem to secure enough vertical lift from a conventional power plant and propeller.

(c) The rotor, after it has raised the aircraft to the required altitude, changes into a fixed wing. This type, on which General Electric has lavished much care, offers some tricky problems in aerodynamics and control during the transition period.

Many people are talking and some are working with convertible aircraft. One small group is completing a machine to be ready for ground tests late this spring. Captain Barnaby describes it thus:

"The rotors are approximately 17 ft. in diameter and their axes are 20 ft. apart. Performance calculations on this aircraft indicate that transition will be a smooth operation, the fixed wings taking on load as the rotor axes are rotated from vertical to horizontal, so that horizontal flight may be maintained throughout the transition. When operating as a helicopter, all control is through the rotor system in accordance with normal helicopter practice. To attain forward motion and to increase speed, the effective rotor discs are inclined forward either by cyclic-pitch control or by tilting the axes mechanically. As the forward speed increases, the fixed wing starts taking an increasing share of the load. This, in turn, permits a larger percentage of the rotor force to be used for forward propulsion. By this procedure the wing is loaded until it is the only lifting surface and the rotors become wholly propulsive, and a smooth transition is accomplished."

To Summarize.—Convertible aircraft are desirable; many solutions are theoretically feasible. A systematic, technical, and material effort is fully justified and in skilled hands might well be successful.

There are analogies between the second topic of this session, Aircraft Design with Boundary-Layer Control, and the first topic, Convertible Aircraft. In both, engineers seek improvement in the low-speed range; both developments are desirable, promising, and plausible; of both, there has been great discussion; in both, nothing much has been done so far (though in boundary-layer control the wind tunnel has been busy at Langley Field, at the N.P.L., and at Goettingen), and in both fields further discussion can only hasten the day when something will really get into the air. So the paper by Albert E. von Doenhoff and L. K. Loftin, Jr., on "Present Status of Research on Boundary-Layer Control" was welcome. Their paper went further than the one by Barnaby, Berkowitz, and Colcord because it summarized wind-tunnel experiments drawn from some 45 references, was a guide to sources, listed possible applications, and offered tentative conclusions. These are the possible applications that the authors list:

"(1) Reduction of profile drag by the elimination of turbulent separation and by increasing the relative extent of laminar flow.

"(2) Increase of the maximum lift coefficient through control of laminar and turbulent separation.

"(3) The use of suction and blowing slots near the rear portion of the airfoil as a means of lateral control.

"(4) The use of boundary-layer control as a means of increasing the efficiency and the range of efficient operating conditions of diffusers and bends.

"(5) The use of boundary-layer control to influence shock boundary-layer interaction at high speeds and, in particular, to eliminate boundary-layer separation following the shock."

And here are the conclusions that come at the end of one of the most scholarly studies ever presented before the Institute.

(1) In low-speed, long-range aircraft, boundary-layer control may eliminate turbulent separation on thick root-section airfoils. Then wings of higher aspect ratio could be employed to give improved values of the lift-to-drag ratio. The analysis was based on data for airfoils having completely turbulent boundary layers extending back from the leading edge.

(2) To obtain extensive regions of laminar flow and correspondingly low profile-drag coefficients obtainable with NACA 6-series airfoils or airfoils of the Griffith type, means must be found for decreasing the sensitivity of the laminar boundary layer to surface imperfections under practical operating conditions. Multiple slots do not appear to decrease the sensitivity of the laminar boundary layer. Area suction does seem to have some stabilizing action, the suction power requirements are small, and further research is desirable.

(3) By boundary-layer control, maximum-lift coefficients of the order of 4.0 can be obtained for airfoil sections of 12 per cent thickness and above without excessive power. Maximum-lift coefficients of the order of 3.0 or 4.0 are effective in decreasing the take-off distance only for airplanes having wings of extremely high aspect ratio.

(4) Boundary-layer control methods for increasing or decreasing the lift of an airfoil independently of the angle of attack has been investigated and has proved to be effective. They would not, however, be any simpler or more effective than conventional control surfaces.

(5) Suction to control separation appears to be a particularly convenient method of increasing the efficiency of short diffusers, because the pressure at the suction slot usually is sufficiently high to eliminate the need for auxiliary pumping equipment.

(6) Investigations have been made of the effect of boundary-layer control on the drag at supercritical Mach Numbers. These tests showed little net decrease in the drag, but the methods might not have been the best. Further research is necessary for reducing the drag and improving the lift and moment characteristics. In particular, continuous or area suction should be investigated at high Mach Numbers.

"Measurements in Flight of Spanwise Wing Loading" by W. Lavern Howland and C. J. Buzzetti (Lockheed Aircraft Corporation), the third paper in the Air-

craft Design Session, did not pretend to look into the future, but it came to grips with a difficult problem. In modern aviation, everything seems to work against the designer of the wing structure: higher speeds and, hence, thinner wings, larger aspect ratio, and sweepback, changes in local lift slope due to compressibility and high Mach Numbers. Even the most advanced theoretical methods of span load distribution give errors. Tunnel tests introduce errors due to differences in Reynolds Number, local roughness, deflection in the full-scale airplane, and tunnel-wall effects. Pressure measurements are not completely satisfactory because they may involve differences between two large quantities, because at the tip too many pressure sensing points are needed, and because shock waves produce nonstationary pressure fields. The test method developed by the Lockheed Aircraft Flight Test Division seeks to avoid this multiplicity of errors by the use of strain gages. In a typical installation, the wing of the PV-2, strain gages were placed at seven different wing stations on the left wing and at one station on the right wing to check symmetry of loads. The strain gages were mounted in the form of a complete bridge unit, and the acceleration at the c.g. of the airplane was measured by a strain-gage-type accelerometer. All measurements were recorded on a twelve-channel recording oscillograph, and bridges were connected directly to the oscillograph element with no intermediate application. Strain gages were energized by regulated d.c. voltage and placed on the lower main beam cap of the single span wing. Careful calibration is an important point; so is location free from torsion and chordwise load effects. The change in wing bending moments at various stations is obtained directly from the oscillograph record as a function of the acceleration at the center of gravity of the airplane. All that is necessary is to make a plot of bending moments vs. g's to multiply the oscillograph galvanometer deflections by their calibration constants (see Fig. 4). The circles in Fig. 4 show the bending moment while the acceleration is increasing and the triangles while the acceleration is decreasing. As a result of many flights, including some on the Lockheed Constellation and the Lockheed Constitution, the test engineers have drawn these conclusions:

First and foremost, that an accurate method has been developed for determining spanwise load distribution in flight. Second, that wing loads on the outer portion of the span are less than those predicted by calculations based on ANC-1 distribution. Third, that strain gages provide a means superior to pressure measurements. Fourth, on prototype airplanes, flight measurements of wing loads should be made for full utilization of the wing strength.

Moreover, with the aid of strain gages, it is possible to evaluate the effects of "speedpaks," tip tanks, radomes, etc., and to determine tail loads in flight. The method with certain refinements can also give drag loads and center-of-pressure locations.

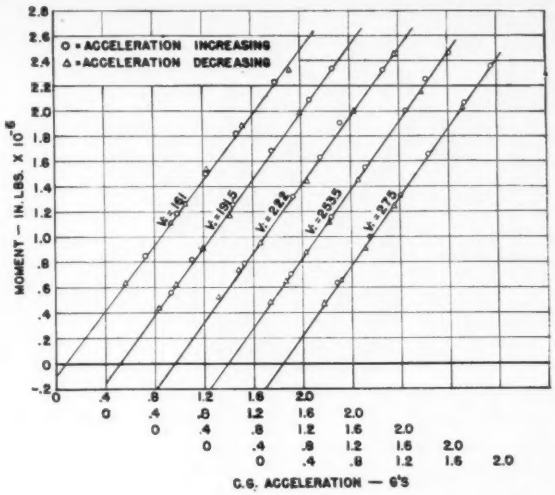


FIG. 4.

Instruments Session

The Instruments Session as a whole proved that our ingenious instrument designers will keep pace always with the general advance of aeronautics. The first paper of the session, "The Pfund Sky Compass" by Joseph B. Matthews, Jr. (Bureau of Aeronautics, Navy Department), carried a special moral. Determined and cooperative experimentation will serve to refine instruments and amplify knowledge; the scientific curiosity of an individual is more likely to induce radical advances. Here is the story of how the Pfund Compass came into being:

"During the war, Dr. A. H. Pfund, of The Johns Hopkins University, constructed a device to measure the polarization of the blue sky as a matter of scientific curiosity. He found that by means of this device it was possible to locate the position of the sun in both altitude and azimuth within a degree or two, not by observing the sun itself but merely the blue sky in the zenith. He found that the device worked even when the sun was obscured by clouds and also when it was somewhat below the horizon, the principal requirement being that an appreciable area of the sky overhead be clear. He names his instrument the 'Twilight Sextant.' In the course of demonstrating the Twilight Sextant, it became evident that this instrument might be useful in aircraft polar navigation, especially in polar twilight areas under favorable weather conditions."

Development of the compass was energetic because in polar regions the astro compass, the radio compass, and the sun compass are either inoperable or unreliable.

The principles of operation of the Pfund Compass are:

(a) Sunlight, entering the earth's atmosphere, is scattered by minute particles, normally more blue light being scattered than light of other wave lengths.

(b) Scattered light at right angles to the incident beam is nearly completely plane polarized.

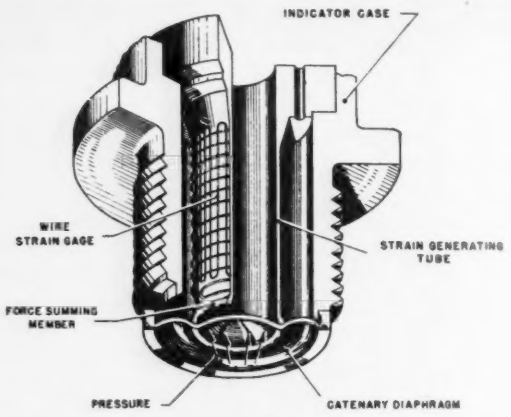


FIG. 5. Pictorial schematic diagram of catenary diaphragm-strain generating tube combination pressure receiver with wire strain gage wind as receiver for electrical coupling system.

(c) The percentage of polarized light decreases as the angle between the scattered and the incident beams departs from a right angle.

(d) The plane of polarization is fixed by the sun, the observer, and the point in the sky being observed.

(e) The percentage of polarization decreases with the amount of light reflected through the sky.

(f) Light from the sky 90° away from the sun is nearly completely polarized under ideal weather conditions, light from other parts of the sky being partially polarized. Therefore, light from the zenith will have maximum polarization when the sun is on the horizon. If the vertical plane containing the zenith, the observer, and the sun can be established instrumentally, then the direction of the sun and, hence, direction is determined.

The optical analyzer used to detect the direction of polarization does not depart from conventional principles and consists of a circular disc of sheet polaroid $4^1/_2$ in. in diameter, on which is mounted in the center a piece of cellophane. With the analyzer there is an azimuth ring, both mounted on concentric centerless gears. Ground tests and preliminary flight tests have been satisfactory.

The second paper of the Instruments Session, by W. A. Wildhack and D. S. Goalwin (National Bureau of Standards) described "A Liquid Oxygen Converter for Aircraft." Gaseous oxygen has many uses in modern technology and in the special kind of "air-conditioning" required in high-altitude flight. Oxygen is conventionally supplied with the gas compressed in steel containers, and both weight and bulk of containers are reduced enormously if the oxygen is in the liquid form. The advantages of supplying oxygen in liquid form have long been recognized, but its continuous evaporation, at the rate of 0.5 to 5 per cent per day has prevented its wide use. Efficient equipment for storage, transfer, and transport of liquid oxygen is economical, and simple, reliable devices to evaporate and dispense the oxygen are essential for convenient utilization of the liquid. Such devices are called "converters" and they must provide: (1) compactness, (2) light weight, (3) simplicity, (4) sturdiness, (5) economy of oxygen, and (6) quick attainment of pressure.

The National Bureau of Standards Converter, developed for the Navy's Bureau of Aeronautics, meets all these requirements. The converter attains operating pressure rapidly and maintains it automatically. The authors' summary describes the instrument:

"In the pressurizing circuit, gravity circulation results from evaporation of liquid by atmospheric heat in an external coil below the liquid level, compressing the resulting warmed gas in the space above the liquid until circulation is stopped by an automatic pressure control. Liquid is vaporized as required in the delivery coil by atmospheric heat. At rates up to 200 liters per min., the gas is warmed to within 5°C. of ambient temperature."

In the third paper of the Instrument Session, C. S. Draper and Y. T. Li (Massachusetts Institute of Technology) described a less novel device than the Pfund Compass but one of more general utility. "A New High-Performance Engine Indicator of the Strain-Gage Type," more specifically defined as a *continuous pressure indicator*, is an invaluable aid to the study of interval combustion engines. Such instruments have been in use for a long time and for as long have suffered from many defects mainly because of undesirable characteristics of the flat-diaphragm type of pressure receiver used with the indicators. Such receivers suffer from excessive sensitivity to temperature, mechanical strain resulting from mounting stresses, and mechanical vibrations in the walls of the pressure chamber as the principal sources of trouble. A semiquantitative discussion leads to the conclusion that the flat-diaphragm-type pressure receiver will always be subject to intolerable inaccuracies under modern operating conditions of modern engines. A new pressure diaphragm with greatly improved performance is shown in Fig. 5; it is practically free from temperature and installation-strain effects and has a greatly reduced sensitivity to vibration as compared with the flat-diaphragm-type pressure receivers. The unit is made up of a catenary diaphragm and a strain generating tube, wound with a wire strain gage. Typical results from laboratory tests and engine runs show that, on the basis of an inaccuracy tolerance of 1 per cent, indicators using the new receiver will be satisfactory.

We stated in the introduction to this review that the papers presented were profound but not revolutionary in scope. The same reproach cannot be leveled at the paper on "The Sperry Zero Reader" by S. Kellogg and C. F. Fragola, of the Sperry Gyroscope Company, because the Zero Reader *is* a new and revolutionary type of instrument.

By combining data from basic flight and navigational instruments in its control unit, it reduces complex demands of attitude, altitude, heading, navigational, and instrument-landing requirements to simply maintaining attitude. It is a synthesizer. By separating the "Plan

of Flight" from the "Mechanism of Flight," flying consists of once setting the plan and then following it by making indicated attitude changes as dictated by deflections of the indicator. It is no longer necessary for the pilot to refer the instrument indications to his "Plan of Flight" mentally and to decide upon the control movements as a result of this comparison.

The new instrument consists of a vertical gyro for pitch-and-roll signals, and a stabilized compass for yaw or heading signals. With this stabilization reference roll, heading and radio beam (VHF, ODR, or localizer) control the vertical pointer, while pitch, altitude, and glide path control the horizontal pointer of the indicator.

The problem of controlling an airplane, when analyzed from the servomechanism point of view, indicates that the control, if sensitive enough, will lead to hunting, particularly when instrument landing is considered, because, as the landing point is approached, the beam becomes narrower—increasing control sensitivity which causes hunting. To increase the performance, derivative control has been added. If localizer signal is considered to be displacement, then bearing angle to the beam (as derived from the stabilized heading) is a measure of the rate of change of beam signal. Since roll determines the rate of turn, or rate of change of bearing angle in this case, it is its derivative. This establishes that radio beam is the displacement, bearing angle is its first derivative, and roll is its second derivative.

In the case of glide path, beam signal is the displacement, with pitch attitude the first derivative. Second derivative has not been found necessary here.

The Zero Reader has many elements. We restrict ourselves to the indicator.

(A) The indicator is a special crossed pointer meter with two mutually perpendicular indicating pointers that move perpendicular to one another over the face of the indicator. The vertical pointer moves from left to right, while the horizontal one moves up and down. The neutral or "zero" position of this unit is indicated when both pointers are centered. The deflection of the vertical pointer is controlled by the sum of bank, stabilized heading, and localizer such that full-scale deflection is equal to maximum localizer signal, 30° heading departure, or 30° roll displacement. The sum of heading and localizer is limited so that a predetermined maximum bank angle will always cancel it—thus providing that the craft does not exceed the maximum bank permissible. The horizontal pointer is controlled by the sum of pitch and glide slope when on instrument approach or by the sum of pitch and altitude when flying constant altitude. Here again, either glide slope or altitude signal, as the case may be, is limited before adding to pitch—thereby ensuring that the maximum pitch angle is not exceeded. The ratios used are full glide path signal, or 300-ft. altitude equals 15° pitch attitude change. In the use of the instrument, the pilot is instructed to concentrate on the intersection of the pointers rather than on the individual pointers and then to execute control movements, without delay or anticipation, in such a direction that the miniature airplane appears to fly to the intersection.

Other instruments include a heading selector, a selector switch, vertical gyro, gyrosyn compass, altitude control, control, etc. The Zero Reader can operate as a flight instrument, as a radio navigation instrument, or as a landing approach instrument.

In any system of operation the pilot has a much easier task than with ordinary instruments, because he flies merely by "following the pointers."

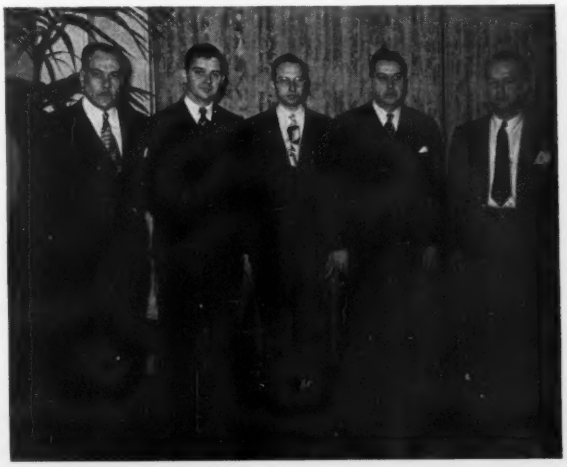
Flight Propulsion

The title of this session is significant—*not* aircraft engines, but flight propulsion. The good old reciprocating engine—still so useful, more powerful, and reliable than ever before—is no longer of research interest. Compressor design, gas-turbine materials, rocket fuels, and similar modern topics hold the field.

It is possible to design a reciprocating engine with little reference to aerodynamics and a slow, conventional airplane without bothering about thermodynamics. But in modern high-speed flight the two sciences come close together, and the paper on "Aerodynamic Hysterisis as a Factor in Critical Flutter Speed of Compressor Blades at Stalling Conditions" by A. Mendelson (Lewis Flight Propulsion Laboratory, N.A.C.A.) explains why. Blades are an integral part of thermodynamic devices such as compressors and of the turbojet engines, and applied aerodynamics alone can explain blade flutter.

Flutter is a self-sustained oscillation, and in finding critical flutter speed the airfoil is assumed to be at low or zero angle of attack and theory and experiment seem to agree very well. In compressor blades, Mr. Mendelson states that flutter occurs at a much lower critical speed

Flight Propulsion Speakers: *Chairman, S. T. Robinson, Sanderson & Porter; Frank E. Marble, Instructor in Aeronautics, Guggenheim Aeronautical Laboratory, California Institute of Technology; A. Mendelson, Lewis Flight Propulsion Laboratory, N.A.C.A.; M. H. Young, Chief, Materials Laboratory, Wright Aeronautical Corporation; and Thomas F. Reinhardt, Rocket Group Engineer, Bell Aircraft Corporation.*



than classical theory would indicate; they suffer from stalling flutter, and he gives two reasons to explain the phenomenon. "*First*, compressor and turbine blades are so stiff compared with ordinary airplane wings that critical speeds obtained by classical calculations are usually above the reasonable operating range, at least for subsonic airfoils. *Second*, the operation of compressors and turbines at high loads near the stall point makes the occurrence of stalling flutter more likely." There are three possible explanations for stalling flutter:

(1) Static instability, due to the negative slope of the lift curve at the stall.

(2) Excitation by von Kármán vortices.

(3) A hysterisis effect. "As the airfoil approaches the stall angle, separation of flow occurs. As the airfoil oscillates about the stall point, the separation of flow is delayed until the position of maximum amplitude is reached. This position will be at an angle of attack greater than that for the stationary airfoil. On the return movement, re-establishment of smooth flow is delayed to an angle of attack below that at which the stationary airfoil would stall. At the stall angle, therefore, the air forces acting depend on the direction of motion, giving rise to the hysteresis loop at stall...." It is this hysteresis effect, or aerodynamic damping, which is the cause of stalling flutter.

On the basis of this assumption, the critical flutter speed at the stall has been calculated mathematically.

This aerodynamic lag, as the author's mathematics show, decreases the torsional damping, and the decrease in torsional damping reduces the critical flutter speed. Thus, aerodynamics comes to the warning and aid of the compressor design.

The influence of aerodynamics on the design of mechanical devices was seen even more strongly than in Mr. Mendelson's paper, in the presentation by Frank E. Marble (California Institute of Technology) of "Some Problems Concerning the Three-Dimensional Flow in Axial Turbomachines." Fifteen or 20 years ago, ventilating and hydraulic machinery was designed by a combination of simple mechanics and empirical formulas. Today the fundamental ideas of aerodynamics, lift, circulation, aspect ratio, down-wash, bound vortices, interference, and cascades dominate the theory of such machinery. As his summary shows, Mr. Marble has certainly fully applied aerodynamic ideas. Some of his sentences read almost as if they were part of a monograph on aircraft propeller design:

"A simplified analysis of the three-dimensional flow in the neighborhood of a stationary or rotating blade row is applied to two problems: (1) estimation of the mutual interference of adjacent and neighboring blade rows in a multistage axial turbomachine, and (2) consideration of the three-dimensional flow in an axial turbomachine operating at conditions differing from the design.

"A solution for the entire flow field is presented for a multistage turbomachine having concentric cylinders for inner and outer boundaries; a particularly simple solution follows for a stage embedded in an infinite

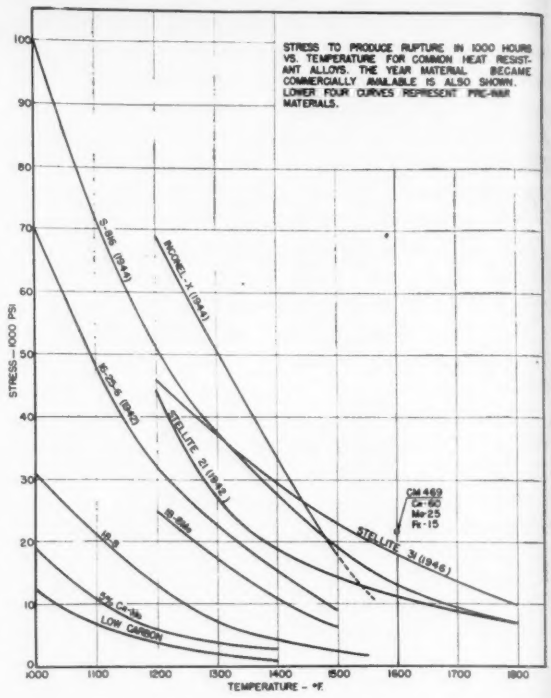


FIG. 6.

number of similar stages. The case discussed in detail is that of a turbomachine having a guide vane row, which imparts solid body rotation, followed by successive similar stages, each of which add or subtract energy uniformly over the radius. The results indicate that the interference of adjacent blade rows may be completely neglected for blade aspect ratios of 1.0 or less, while for aspect ratios in excess of 3.0 the interference may become a predominant influence.

"Consideration of operation at conditions other than the design condition involves solution of the 'direct problem'—that is, one where the blade geometry rather than the blade loading is prescribed. This problem is reduced to the solution of an ordinary differential equation by linearization and by satisfying the boundary condition only at the trailing edge of the given blade row. The process is illustrated by a moving blade row that imparts solid-body rotation to the fluid, the most interesting feature of which is the influence to the off-design performance of the rate at which the radial adjustment of flow takes place. It is clear that, for blades of low aspect ratio, the radial adjustment is nearly complete by the time the trailing edge is reached, while for blades of extremely high aspect ratio almost negligible radial adjustment has occurred. Consequently, it is found that the distortion of axial velocity profile caused by operating off-design condition may be significantly less for low than for high aspect ratio blades."

M. H. Young (Wright Aeronautical Corporation) showed much good sense in his paper "Designing for Gas-Turbine Materials," whose keynote came in its last paragraph:

"With proper design consideration for the limitations of our present alloys and with improving background for understanding these limitations, we should be able to affect substantial improvement in the performance of future turbojet and turboprop engines without resorting to wishful thinking about the Utopian material that would permit unlimited power and efficiency with a minimum of drafting room labor."

Mr. Young lives up to this statement and gives specific guidance in meeting the limitations he speaks of. His paper does not lend itself to an abstract, but many of his remarks are worth quoting:

(A) "When operating temperatures pass about 1,000°F., we have three variables with which to be concerned: (1) stress, (2) temperature, and (3) time at temperature. Each of these factors must be the subject of the painstaking investigation previously reserved for stress analysis alone."

(B) Referring to Fig. 6 "on the basis of the stress to produce rupture in 1,000 hours at the temperatures shown, two well-known alloys in the forgeable group, S-816 and Inconel X, and two cast alloys, Stellites 21 and 31, are the best of the materials represented. Of the four, Inconel X is decidedly superior in strength at temperatures up to about 1,450°F., but above this temperature Inconel X loses strength more rapidly than the other three materials, becoming the worst of the group just under 1,550°F. This general relationship holds true even for times much under 1,000 hours, although crossover temperatures may shift upward for shorter times." Fig. 7 "shows the effect of time under stress and temperature. The greater stability of S-816 over Inconel X at 1,500°F. is indicated by the fact that, while Inconel X is initially stronger than S-816, it falls lower than S-816 after a time of less than 1,000 hours. We have initiated the above discussion with a reference to the accepted approach to aircraft-engine design development because it affords an excellent example of the necessity for a new and thorough understanding of high-temperature materials on the part of design engineers."

(C) From Fig. 7 "it is also seen that the operating life of such parts as turbine blades must be decided upon in advance, or we run the risk of choosing and designing around a material whose lack of stability at the operating temperature make it superior to other possible alloys for only part of its expected operating life."

(D) "Creep rates of high-temperature alloys become extremely important in considering design stresses and materials for high-temperature bolting. It is easy for the designer to forget that, at temperatures over 1,000°F., the residual tension in a bolt or cap screw—and, hence, the clamping stress—will usually drop appreciably as a result of creep."

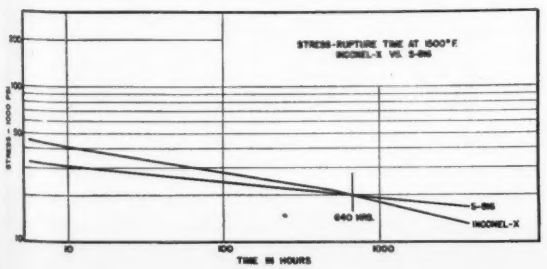


FIG. 7.

(E) "Ceramic coating of alloy parts has been of specialized value but has not proved to be a permanent protection. Solid ceramic turbine blades have for some time seemed to offer the possibility of increased operating temperatures, but their brittleness and low resistance to thermal shock have prevented their extended use in practice. Metal bonded ceramics may well be a more immediate answer to the use of ceramic turbine parts. Here again there is only meager evidence to support such a contention, and, generally, the only safe prediction for the future is that we must certainly know more about the materials already in use."

From these quotations it is seen that one must read and digest every line of Mr. Young's paper.

In judging rocket-motor performance, the specific impulse, $I_{sp} = I/W$, where I = impulse created in a given period and W is the fuel consumed in the same period, is used more and more frequently as a measure. It would seem, therefore, a reasonable plan to use fuels rich in hydrogen. But fuels rich in hydrogen have low specific weight, and this means large tanks and increased overall weight of the jet propulsion system. Therefore, an additional guide to the selection of a propellant is the product (specific impulse × specific weight). Whatever constants or functions are employed, the problem of fuel section is more complex than might be thought at first. Hence the study "Factors Affecting the Range of Rocket-Powered Aircraft," by Thomas F. Reinhardt (Bell Aircraft Corporation), is timely and useful. Mr. Reinhardt presented a method of weighing the relative importance of specific impulse and propellant density for rocket-propelled aircraft. He showed that specific impulse and density are of equal importance for aircraft with low wing loading. Specific impulse becomes more important, however, for high wing loading and high ratios of propellant weight to total weight.

Symposium—Cloud Physics

The American Meteorological Society is a modest group. Year by year this Society holds a joint session with the Institute of the Aeronautical Sciences, and never do the members of the Institute see anything but abstracts of the papers. On the basis of these abstracts, we can make only the briefest comments.

There were in the Cloud Physics Session three closely allied papers: (1) "Methods and Techniques for the Study of Atmospheric Nuclei, Clouds, and Precipitation," by Vincent J. Schaefer (General Electric Research Laboratory); (2) "Experiments on the Artificial Production of Precipitation at Wilmington, Ohio—1948," by R. D. Coons, R. C. Gentry, E. L. Jones, and Ross Gunn (U.S. Weather Bureau); (3) "Larger Scale Seeding of Stratus and Cumulus Clouds with Dry Ice," by Irving Langmuir (General Electric Company).

Symposium—Cloud Physics: *Chairman, Arthur F. Merewether, Superintendent of Meteorology, American Airlines, Inc.; Vincent J. Schaefer, General Electric Research Laboratory; R. D. Coons, Physical Research Division, U.S. Weather Bureau; and Irving Langmuir, Associate Director, Research Laboratory, General Electric Company.*

To understand clouds and precipitation and the formation of rain and snow is a difficult task. To produce rain and snow is immensely difficult. One must use three tools: (1) laboratory research; (2) field research and observation; (3) flight operations. The laboratory work must be fascinating and relatively easy. On the basis of no information from the American Meteorological Society, we can *imagine* that the research worker constructs his own vapors, sprays, or clouds. He makes them saturated, partly saturated, cooled, and supercooled. Into these creations he drops pellets of carbon dioxide, snow, water drops, and other "nucleating agents" (a horrible word whose originator should be made to suffer), and he rejoices to see rain or snow appear in the laboratory. The principle of using nucleating agents appears simple and logical. Nor is it too difficult to observe nature or as Mr. Schaefer puts it "to reach a better understanding of the various physical processes that combine to cause the genesis, growth, maturity, and decline of clouds, and, in particular, the basic features that combine to form various types of precipitation." We can imagine elaborate and systematic experiments, photography, lantern slides, moving pictures, black and white, and color studies. But when it comes to producing precipitation, Messrs. Coons, Gentry, Jones, and Gunn say sadly: "The crucial difficulty in the assessment of data was to separate out the natural effects from those artificially induced." The same difficulty would arise in judging the incantations of an African witch doctor. Still more sadly, Messrs. Coons, Gentry, Jones, and Gunn say: "There is no indication that artificial cloud modifications induce self-propagating storms. The experiments suggest that cloud seeding techniques are of relatively little economic importance."

In the light of such conclusions, it is not surprising that the Air Force has discounted experiments in weather control.

But it is always dangerous to say that something in technology is impossible. Dr. Francis W. Reichelderfer, Director, U.S. Weather Bureau, said in a luncheon address that the Weather Bureau would still continue experiments, though in another fashion, and Dr. Irving Langmuir (General Electric Company) in the last paper of the session, "Progress Report on Project Cirrus," reported some striking achievements in the making of holes in clouds to permit airplane landings.

"Project Cirrus is a joint operation of the Signal Corps, the Navy, the Air Force, and the Research Laboratory of the General Electric Company. Its object is the study of the production of rain and snow and of modifications in these processes by artificial seeding. Up until December 15, 1948, 56 flight tests were made. In general, the procedure has been to have two planes—B-17's—equipped with photopanels that give, at intervals of about 45 sec., the time within seconds, the altitude, the air speed, and the heading of the plane. Photopanel data were also taken at all times when photographs of clouds were taken. From these data the flight path with respect to the air through which the plane was moving was determined accurately to within a few tenths of a mile. Checks were made whenever possible of the actual position with respect to the ground by radio bearings or observations of points on the ground. In 24 cases, stratus cloud systems were studied, and in 19 cases cumulus clouds were studied. In 35 flights positive indications of cloud modification, conversion of supercooled clouds to clouds of ice crystals, were obtained."

Dr. Langmuir achieved some remarkable results. Huge holes five times the area of Manhattan can be melted in stratus clouds to permit airplane operations by seeding the clouds with dry ice. Stratus clouds have great horizontal extension and relatively low altitudes, between 2,000 and 7,000 ft. To prove that the holes melted in such clouds during the experiments were produced by man, Dr. Langmuir related, hole patterns were made to include the letter "L," a racetrack, and one like that found in an enlarged doughnut. In one experiment he seeded dry ice into a vast nonturbulent stratus deck almost 3,000 ft. thick. The airplane's crew distributed the dry ice at the rate of only six-tenths of a pound a mile to form a huge 28-mile-long gap. The gap was distinct within 40 min. of the seeding, and through a clearing of 100 sq. miles all details of the ground could be seen. During another flight, an L-shaped pattern 50 miles square was cut in stratus clouds over Cape Cod Bay, Mass. Dr. Langmuir stressed that "an easy but false assumption" in connection with clearing holes in the overcast would be that the more dry ice used, the better the results. "Overseeding" would cause the formation of an ice crystal fog denser than the cloud itself.

Symposium—Upper Atmosphere

One can forgive the American Meteorological Society for not making available papers on Cloud Physics, since research in rain making has been abandoned for the time being, and in the Symposium on the Upper Atmosphere we could conceivably dispense with three of the papers, no matter how valuable they are to scientists: (1) "Solar Activity and the Earth's Atmosphere," by Donald H. Menzel (Harvard University); (2) "Geophysical Aspects of Cosmic Rays," by James A. Van Allen (The Johns Hopkins University); (3) "Meteorological Structure of the Ionosphere," by L. V. Berkner (Carnegie Institute of Washington).

But three of the papers should somehow be made to appear in the JOURNAL OF THE AERONAUTICAL SCIENCES. Thus, "Probing the Upper Atmosphere with Meteors," by Fred L. Whipple (Harvard College Observatory), deals with questions that are vital to the work of the "advanced" aeronautical engineer, as the following summary shows:

"This paper concerns research on the upper atmosphere and high-velocity ballistics by means of photographic observations of meteors from two stations. The cameras are equipped with rotating shutters so that trajectories, velocities, decelerations, and brightness of meteors can be measured. The results include the determination of a seasonal effect in upper-atmosphere densities, the atmospheric density curve to 90 km., and certain ballistic results.

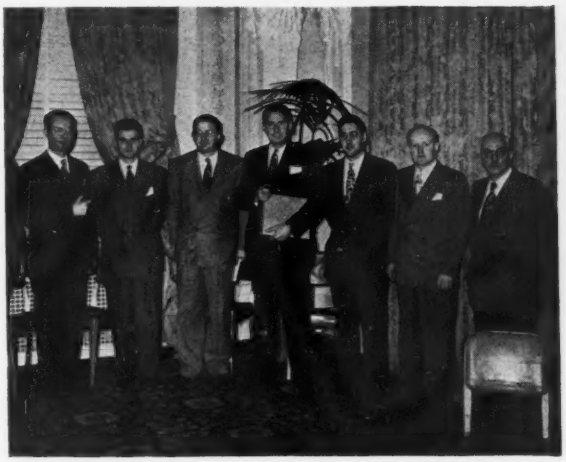
"Special attention is given to the problem of an extensive ionized region accompanying the moving body of many meteors observed by radio techniques. Crumbling and breaking of the meteoroid (in addition to vaporization) is indicated by split meteors in the Harvard Collection. An analysis of these trails indicates the aerodynamic forces at work in the phenomenon. Numerical, statistical, and theoretical results are presented.

"Some problems involving the mean free paths of molecules, atoms, and ions at supersonic velocities in the upper atmosphere are discussed. In view of the fact that ballistic problems are altered completely at Mach Numbers of the order of 100, some conclusions and problems of the basic meteor phenomenon are discussed."

Since everything relating to the properties of the Upper Atmosphere is vital, we make the same plea for the two other papers whose summaries follow:

"Upper Atmosphere Measurements by Means of Large Rockets," by T. A. Bergstralh (Naval Research Laboratory). "Upper atmosphere investigations have been carried out in several fields over a period of over 2 years. Accurate ambient pressures were determined up to 70 km., and somewhat less accurate measurements were made up to 120 km. Ambient temperatures were determined from the variation of pressure with altitude and from ram-pressure measurements.

"Cosmic-ray measurements have been made by means of Geiger counter tube telescopes and cloud chambers. The vertical distribution of ozone in the atmosphere was determined from spectra obtained by flying solar spectrographs in the rockets. Rough measurements of effective electron densities have been obtained."



Symposium—Upper Atmosphere: *Chairman, Capt. H. T. Orville, U.S.N., President, American Meteorological Society (missing from photograph); Donald H. Menzel, Professor of Astrophysics, Harvard University, and Associate Director for Solar Research, Harvard College Observatory; Fred L. Whipple, Associate Professor of Astronomy, Harvard College Observatory; S. F. Singer, Applied Physics Laboratory, The Johns Hopkins University; L. V. Berkner, Acting Director and Chairman, Section of Exploratory Geophysics of the Atmosphere, Carnegie Institute of Washington; T. A. Bergstralh, Physicist, Rocket-Sounding Research Section, Naval Research Laboratory; E. G. Droessler, Meteorologist, Geophysics Branch, Office of Naval Research; and Dr. Marcus O'Day, Discusser.*

"The Navy Has a Skyhook", by E. G. Droessler (Office of Naval Research). "For over 2 years, the Office of Naval Research has been sponsoring research on high-altitude balloon ascension. A comparatively successful plastic balloon has been developed. To utilize this new vehicle, a broad program of upper-atmosphere research is being performed under Project Skyhook. Project Skyhook has made 52 flights to date, carrying heavy loads to altitudes in excess of 30 km. Scientific instruments are carried aloft to collect new information on the cosmic rays, biological phenomena, meteorological parameters, etc."

A 20-min. 16-mm. color film showing the launching techniques and the balloons in flight accompanied this paper.

Transonic and Supersonic Aerodynamics

In the first sentence of this article, we said that the Aerodynamics Sessions were not dramatic, but they were significant. "Plus ça change, plus c'est la même chose," and it was reassuring to learn that the theory of dynamic stability remains substantially unchanged at high speeds. Designers can design really fast aircraft without alarm, at least as far as stability goes. Busemann's paper, the third in the session, was remarkable on two grounds. First, it presented the whole difficult

Transonic and Supersonic Aerodynamics: *Chairman, R. G. Robinson, Assistant Director of Aeronautical Research, N.A.C.A.; H. F. Ludloff, Associate Professor, New York University; I. C. Statler, Aerodynamicist, Flight Research Department, Cornell Aeronautical Laboratory, Inc.; and A. Busemann, Compressibility Research Division, Langley Aeronautical Laboratory, N.A.C.A. (Arthur R. Kantrowitz, Graduate School of Aeronautical Engineering, Cornell University, is missing from this picture.)*

philosophy of drag in the transonic region without a single formula, an achievement never equalled before at Institute Meetings. Second, it robbed of some of its terror the transonic region in which there can arise queer combinations of subsonic and sonic flows; where the lower critical Mach Number can be calculated but the higher Mach Number of shock flow cannot; where the aerodynamicist throws up his hands; and where, as a final horror, the wind tunnel is no longer a reliable instrument. Considering the difficulties of the transonic region and the few years that they have been on the scene, aerodynamicists are not doing so badly after all.

C. S. Gardner and H. F. Ludloff (New York University) wrote on the "Influence of Acceleration on Aerodynamic Characteristics of Thin Wings in Supersonic and Transonic Flight." The paper was written by courageous and well-informed men, masters of mathematical analysis and modern aerodynamics; it represents patient and careful research. After the readers and the editors get through with the paper, we shall have something really valuable in the JOURNAL. In the meantime, let us quote some sentences that prove we may expect good things to come:

"The path of a uniformly accelerated, two-dimensional thin airfoil can be represented in the x-t plane as a strip between two parabolic arcs. If we assume the airfoil to produce small disturbances, any point inside the strip can be considered to be a source of disturbance waves propagating with sound speed. The velocity field can be derived from a perturbation potential, which has to fulfill the differential equation of sound waves, and the solution of this equation can be represented as an integral over Temporary Sources (Possio's Solutions), which are distributed over this strip.

"This means that during the subsonic flight, the whole previous history of the airfoil motion will influence the pressure distribution, lift, and drag, while during the supersonic flight the airfoil flies through undisturbed air."

"Thus, it may be noted that the aerodynamic characteristics at $M = 1$ will be different, depending on whether the airfoil has been accelerating from subsonic speeds or decelerating from supersonic speeds.

"The present investigation deals with the change of aerodynamic characteristics during a decelerating flight, starting at supersonic speeds. It turns out that the influence of deceleration is relatively small at supersonic speeds (slightly larger, if the airfoil flies at a finite angle of attack). But the effects become considerable in the transonic range and show a marked maximum at $M = 1$, although all parameters remain finite and vary continuously."

The theory of dynamic stability has never been a simple subject. Still it was possible to make not too laborious an analysis by making two assumptions: (1) The speed remains constant during a dynamic oscillation; and (2) the significant stability derivatives are independent of the frequency of oscillations.

I. C. Statler (Cornell Aeronautical Laboratory, Inc.), in his paper "Dynamic Stability at High Speeds from Unsteady Flow Theory," shows once again that these two assumptions and the simplified theory are reasonably accurate for flight in the incompressible fluid. But in approaching flight at high speeds, Mr. Statler poses the following uncomfortable questions for dynamic stability at high speed:

(1) Should the effects of frequency upon the stability derivatives be included?

(2) Should the higher order derivatives be included?

(3) Is the simple time lag assumption defined by the classical time lag term, $M\omega$, sufficiently accurate?

Mr. Statler, with much courage and knowledge, analyzed the problem by taking into account (1) the lift distribution over a harmonically oscillating thin airfoil in subsonic compressible flow; and (2) the effect of the oscillating wing wake upon the horizontal tail surfaces. A recent U.S.A.F. fighter-type jet airplane was the subject of the calculations.

He found the stability derivatives to be complex functions of frequency and Mach Number, and, if we understand his discussion rightly, these are the conclusions:

(1) The influence of frequency becomes increasingly more important with increasing Mach Number. The problem is *not* critical, however.

(2) The inaccuracies in using the classical $M\omega$ are probably no greater than those of the original theoretical or the experimental data.

(3) If the designer chooses to use the more correct values of the down-wash as obtained from the unsteady theory, instead of being content with $M\omega$, then he can compute the derivatives from general charts as func-

tions of reduced frequency, Mach Number, and tail position with respect to the wing.

A more complete report is soon to be published by Cornell Aeronautical Laboratory, Inc. Every aerodynamicist working in this field will want to read it. But for the time being, he can apparently use the simplified theory of dynamic stability without too great uneasiness.

"The Problem of Drag at High Subsonic Speeds," by Adolf Busemann (Langley Aeronautical Laboratory, N.A.C.A.), contains original thought. It is relatively easy to find the lower critical Mach Number, the speed at which the local velocity over a body first reaches the speed of sound. Mr. Busemann attempts a much harder problem: To find the higher critical Mach Number, the speed that marks the first appearance of shock waves in a nonviscous fluid. There are indeed some solutions of shock-free potential flow with a mixed subsonic-supersonic velocity pattern. But genuine potential flow with a mixed pattern are the exceptions. As a rule, the flow past a given body at high subsonic speeds leads to a unique solution containing shock waves. By finding such solutions for two-dimensional cases and by extending the main conclusions to three-dimensional cases, the author has answered many troublesome questions. He discusses qualitatively, basing considerations on nearly two decades of research, the phenomena or effects of supersonic enclosures; curvature of the body contour; infinitesimal variations of the body contour; the decelerated supersonic channel flow; mixed flow in a curved channel; and new aspects of subsonic mixed flow.

The Berlin Airlift

(*Continued from page 25*)

plane with the right characteristics. In my opinion these include: ease of maintenance, high utilization, direct loading and unloading, maximum useful capacity, probably 25 tons, a range of 3,000–4,000 miles, and a low cost of operation.

"You will note that I have said nothing about speed. Naturally, this is a consideration and should probably be set at about 250 m.p.h. But in this era of jet and supersonic speeds it is important, I think, not to transfer this emphasis on speed to the field of air transport, where it is in fact a secondary consideration. . . ."

Importance of Integration

"Among other things, Vittles has underscored the importance of integration. With full control over both its Air Force and Navy elements, M.A.T.S. was able to marshal its resources for Vittles with a minimum delay and confusion. Had the two Services been separate, one may imagine the possibilities of duplication in functions of command, facilities, communications, weather, and all other services. Today, the Air Force and Navy crews are receiving uniform training for Vittles at one school. In Germany they are flying side by side in one operation. Their logistic support comes to them through one channel, over one air route, in planes of their own command. Certainly this is reward enough for the trials and tribulations of unification. . . .

"No one knows how long Operation Vittles may last. We in the Military Air Transport Service, responsible as we are for maintaining the operation fleet and training the replacement crews, in addition to other support functions, are planning on an indefinite duration. Of this you can be sure—Vittles is and will remain our first priority. To it we will devote all our resources and all our energies—proud to have so large a share in so great a mission."

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be sent directly to the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Trends in the Application and Maintenance of Turbojet Engines

by

R. P. KROON* and R. B. ROGERS†

Westinghouse Electric Corporation

Introduction

THE CURRENT PHASE of development of turbojet engines may be likened to the "Model T" era of automobiles. There is considerable progress from the original "one lungers," but there is still the simplicity, the ruggedness, and the lack of sophistication that marked the "Model T" phase in automobile design. Too, like the Model T, today's turbojet engine has already shown itself, in many respects, to be an able and dependable performer.

The evolution of the present-day jet engine in something less than a decade, even under the stimulus of forced draft engineering development necessitated by military requirements, has been remarkable. But it is to be expected that considerable improvement will be made in the next few years in several directions.

The large majority of the jet engines produced so far were "simple open cycle" gas turbines, with fixed exhaust nozzle area. In most cases the rotating system consisted of a single compressor rotor, coupled to a single turbine rotor. The control used was almost universally either the constant r.p.m. type or the throttle valve barostat type, operated by a single lever. With these simple features have been associated certain limitations in operation and performance.

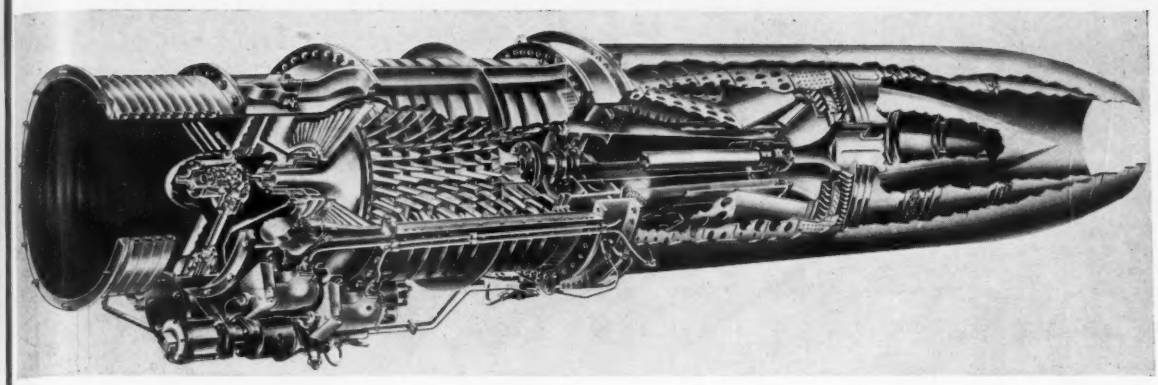
Incentives for improvements involving increased complexity in future jet engines are manifold and doubtless of a more stringent nature than those that led to the abandonment of the Model T automobile. It is one purpose of this paper to analyze these motives in some detail.

(*a*) *Better Performance.*—High fuel consumption has been the most serious drawback of the jet engine. Any improvement in fuel economy, provided it is not offset by a disproportionate increase in weight or volume, generally results in a more desirable engine. Even with the present engine arrangement, considerably better fuel consumption can be obtained by improving the efficiency of the main components—the compressor, combustor, turbine, and exhaust nozzle. In this manner, fuel consumption has been reduced some 30 per cent in the last 4–5 years. Higher pressure ratios, applied to the simple gas turbine cycle, result in a better power-plant efficiency, provided that the efficiency of the components can be maintained at a high level. In order to obtain higher pressure ratios, some of the turboprop designs, such as the British THESEUS and the CLYDE, have adopted multiple compressor and turbine rotors. While this, of course, results in added complexity, the use of compound rotors will also find its way into turbojet engines wherever conditions warrant it.

Presented at the New York Section Meeting, I.A.S., December 2, 1948.

* Manager of Engineering, Aviation Gas Turbine Division.

† Manager of Service Department, Aviation Gas Turbine Division.



Apart from obtaining better power-plant efficiency, there is the incentive to obtain as much power as possible out of the power plant under any flight conditions. As is well known, in a simple fixed exhaust nozzle area machine, the peak temperature in the engine—the turbine inlet temperature—varies with the air temperature and pressure at the compressor inlet. With cold ambient temperatures and high flight speeds, the maximum temperatures in the engine may be considerably below what the materials have been designed to stand at normal temperature or under "hot day" conditions. Therefore, the power produced is less than what the engine is able to supply safely. Obviously, to take advantage of all the power the engine is capable of delivering, some modifications within the engine are required. Such modifications involve additional features in the engine, as well as in its control.

(*b*) *Range of Operation.*—Apart from obtaining better efficiency and all available power out of the engine, there is the trend to extend the useful range of operation. This includes operating at higher altitudes and at high flight speeds, resulting in higher inlet pressures and temperatures to the engine. It also involves the quest for ignition and starting at extremely low temperatures.

As inlet temperatures increase, light alloys that were adequate for lower temperature have to be replaced by steel. Higher inlet pressures lead to increased wall thickness and therefore to a heavier engine. Higher altitudes mean additional requirements on the combustion chamber, resulting generally in increased size and weight. This type of requirement also includes operating under unusual maneuvering loads—*g* loads and gyroscopic forces—which are peculiar to high-speed flying and which affect structural features of the engine, as well as, possibly, the lubricating and fuel system.

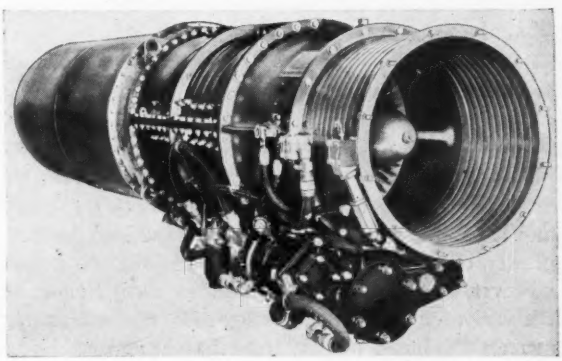
One lubrication problem is the requirement for ability to accommodate extreme transition from "hot day" to sub-Arctic starting conditions as a matter of everyday occurrence. This arises out of the hitherto unknown practice of achieving required cruise economy in multiengined aircraft by cutting out some units of the power plant entirely during flight. Engines may start under "hot day" conditions before take-off yet be restarted under sub-zero temperature in flight prior to let-down.

(*c*) *Increased Reliability.*—With increased operating experience on jet engines, several ways have suggested themselves to provide increased reliability. Some of these have to do with the handling of fuel within the engine in such a manner that under no circumstances can fuel (or other fluids for that matter) accumulate within the engine to cause a fire hazard. Other precautions point toward the duplication of vital accessories, in order to be absolutely sure of power when trouble occurs on the primary accessory. There may be a requirement for the engine to keep operating safely, even though the oil flow is briefly interrupted.

Still other additions to the engine have to do with automatic restarting in flight, after a momentary interruption of fuel flow to the engine such as may be caused by shifting from one fuel tank to another.

While engine icing conditions occur infrequently, the desire for all-weather flying may make anti-icing protection for the engine mandatory.

(*d*) *Other Services of the Engine.*—Whereas in the early days of jet propulsion it was considered a creditable accomplishment for the engine to push the plane



The Westinghouse J30 (19XB) axial-flow turbojet, which was selected as the basis for the service statistics used in this article.

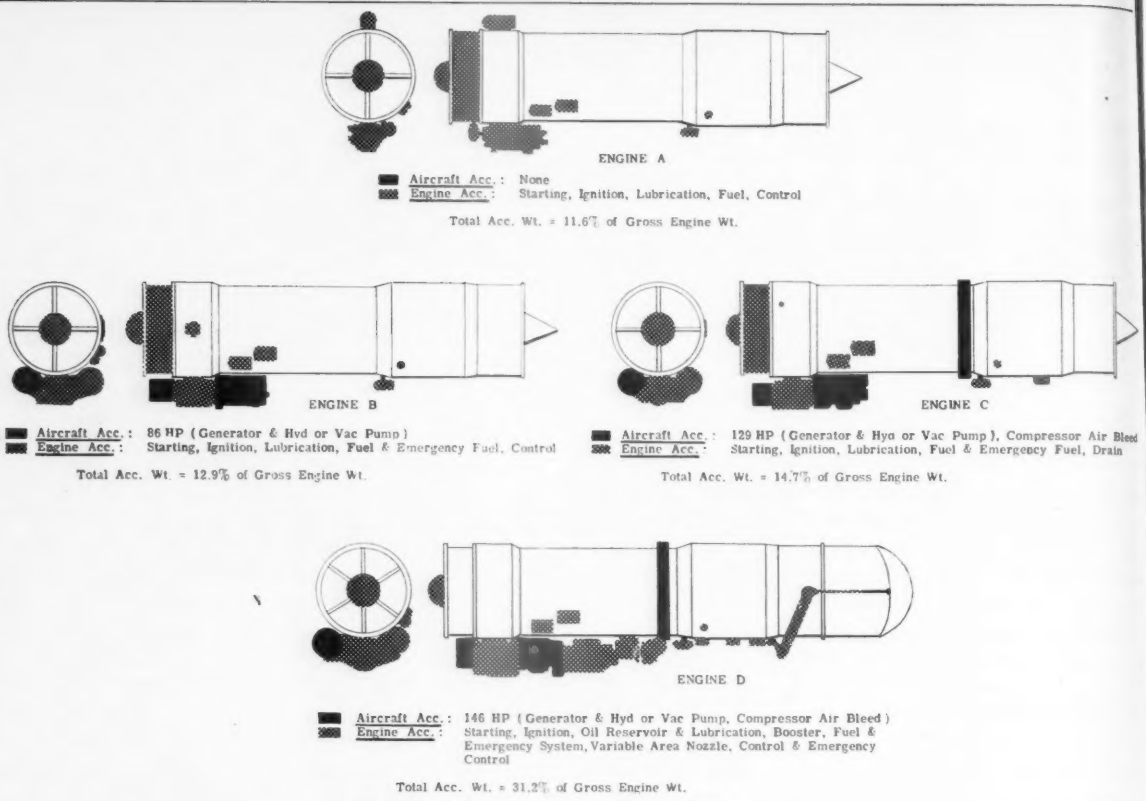

ENGINE A
Aircraft Acc.: None
Engine Acc.: Starting, Ignition, Lubrication, Fuel, Control
Total Acc. Wt. = 11.6% of Gross Engine Wt.
ENGINE B
Aircraft Acc.: 86 HP (Generator & Hyd or Vac Pump)
Engine Acc.: Starting, Ignition, Lubrication, Fuel & Emergency Fuel, Control
Total Acc. Wt. = 12.9% of Gross Engine Wt.
ENGINE C
Aircraft Acc.: 129 HP (Generator & Hyd or Vac Pump), Compressor Air Bleed
Engine Acc.: Starting, Ignition, Lubrication, Fuel & Emergency Fuel, Drain
Total Acc. Wt. = 14.7% of Gross Engine Wt.
ENGINE D
Aircraft Acc.: 146 HP (Generator & Hyd or Vac Pump, Compressor Air Bleed)
Engine Acc.: Starting, Ignition, Oil Reservoir & Lubrication, Booster, Fuel & Emergency System, Variable Area Nozzle, Control & Emergency Control
Total Acc. Wt. = 31.2% of Gross Engine Wt.

FIG. 1. Trend of turbojet accessory development.

around, more and more is required of the engine in the way of additional services to the airplane. It is natural to think of the compressor of the engine, being an efficient component, as a means to furnish compressed air for other services as well, such as for cabin supercharging or aircraft deicing. As the engine is also a prolific producer of heat, longing eyes are cast in the direction of using this heat for aircraft purposes.

More and more horsepower is now being required from the engine to supply electric power and hydraulic power to the airplane. On a medium-sized engine several hundred horsepower are now required for this kind of auxiliary power alone.

Some functions that were traditionally airplane functions are being taken over by the jet engine. For example, while some early jet engines operated with an oil reservoir that was supplied with the air frame, many of the later engines contain their own integral oil tank.

Each of the trends enumerated under (*a*), (*b*), (*c*), and (*d*) above in itself contributes in a way to the complexity of the engine and its accessories. It is not, however, until one observes the cumulative effect of the various trends that the magnitude of the resulting increased volume, weight, frontal area, and complication becomes apparent.

As an illustration, the authors have chosen a medium-sized engine and shown it in various stages of development. Some forms of the engine shown have actually been built; others are based on careful engine studies. It should be explained that the designs shown may not be, in the long run, the smallest and lightest to achieve the purpose; on the other hand, the engines with additional accessories correspond, in general, to more recent studies and, hence, in comparison, they benefit from improvements in the art made in the interim. Altogether, it is believed that the picture presented is a realistic one.

Fig. 1 shows a side view and front view of the engines and is intended to show the space requirements of each configuration. In the figure, black areas indicate aircraft accessories and the stippled areas represent engine accessories. There is also shown the weight of the involved accessories and external hardware on the engine as a percentage of the gross engine weight. While aircraft accessories are shown, the computed accessory weight included only the drives necessary for these and not the aircraft accessories themselves.

Engine A of Fig. 1 is a "booster" type of engine—that is, it contains no accessories whatsoever for the benefit of the airplane. The engine accessories are a bare minimum needed for engine operation. They involve starting, ignition, lubrication, and the fuel and control system. In this case the total weight of the accessories amounts to 11.6 per cent of the gross engine weight.

In Engine B there were added drives for generator and hydraulic or vacuum pump for airplane services, as well as an emergency fuel system for the engine. This

resulted in a gear box redesign. At the same time it was found possible to make some weight-savings in the lubricating system. The resulting overall accessory weight came out to be 12.9 per cent of the gross engine weight. It is clear that going from Engine A to Engine B involved considerable change in frontal area.

Engine C performs the same functions as Engine B, but the horsepower to the aircraft accessory drive is increased 50 per cent and a manifold is added to provide compressor air bleed for aircraft service. A fuel drain system is added, and several refinements are made in the engine accessories. The total accessory weight increased to 14.7 per cent of the overall engine weight.

Engine D represents a study of an advanced engine, which would be still more useful from an aircraft standpoint. Compared with Engine C, Engine D furnishes again 13 per cent more aircraft accessory power. In this study the engine is provided with anti-icing equipment, an integral oil reservoir, a fuel booster pump, and a complete emergency control system. The engine is equipped with a variable area nozzle and its control. As Fig. 1 shows, these features do not come free, but involve a considerable addition to the total installation volume. For this study the accessory weight totaled 31.2 per cent of the gross engine weight, which is an amazingly high percentage, being almost three times as much as that of booster Engine A.

Service Experience

To this point, the contrast of the inherent simplicity of the present basic turbojet engine with the growing complexity of the complete power-plant installation has been emphasized. It is desirable to look at service experience with this type of engine as compared to the reciprocating engine, with concentration on the details of jet troubles. First, a glance at reciprocating engine history as compiled by C.A.A.:

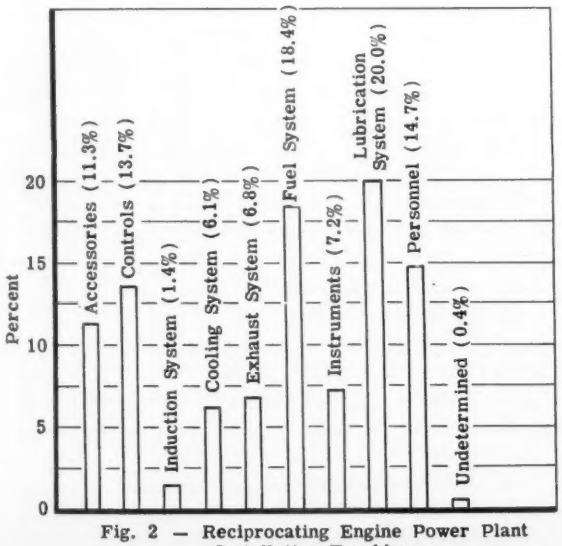


Fig. 2 — Reciprocating Engine Power Plant Installation Troubles

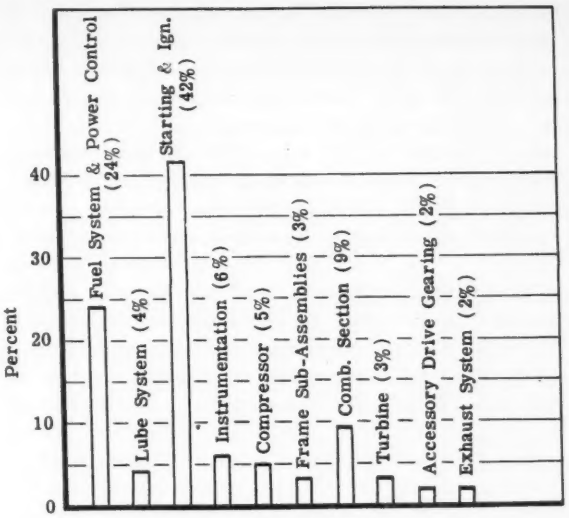


Fig. 3 — Turbo-Jet Engine Troubles

A paper presented by John W. Baird, Assistant Chief, Power Plant Engineering Division of C.A.A., before the Society of Automotive Engineers has been used as the source of statistics. It deals with commercial experience with reciprocating engines over a period of 10 years, ending with 1947. Title of the article is "Survey of Power Plant Installation Troubles." Mr. Baird presents a chart showing relative frequency of troubles with various elements of the power-plant installation; the chart is reproduced herewith as Fig. 2. For practical purposes, the "Personnel Error" factor will be omitted from this discussion, inasmuch as the primary interest is in engineering considerations reflected by service experience.

In the chart, the lubrication system ranks first as trouble maker, at 20 per cent, with the fuel system running a close second at 18.4 per cent. Omitting "Personnel," controls and accessories are third and fourth, respectively, at 13.7 and 11.3 per cent. Other sources are relatively minor in comparison.

In the turbojet, of necessity, the picture is somewhat different, particularly because of the fact that the engines are still in a state of rapid engineering development, which renders it difficult to evaluate a given source of service interruption as a transient by virtue of imminent design changes or a permanent feature that must be improved to the point of ordinary dependability. However, the inherent characteristics of this type of engine, as compared with the reciprocating engine, are revealed by a study of trouble statistics.

Another chart, Fig. 3, differently subdivided as to components, shows relative frequency of power-plant troubles occurring in a service jet aircraft over a period of some 22 months. Source of the statistics is the Westinghouse Model 19X-B, AN designation J30, turbojet installed in the Navy fighter FH-1 Phantom, built by McDonnell Aircraft Corporation. While the J30 engine represents design techniques of 3–4 years ago and does not typify what can be expected of more

recent engines, a review of the relative frequency of various troubles remains of interest.

Primary reason for the different subdivisions is the fact that this chart does not include troubles ascribable to installation—that is, it does not go beyond the "customer's connections" to the engine and its accessories. Some of the troubles represented, however, did arise out of operating procedure or were contributed to by installation deficiencies, as will be discussed in more detail.

The relatively high incidence of starting and ignition system difficulties is partly due to the exacting starting power requirements but, more particularly, is the result of the relative newness of the system components for application under the particular conditions encountered.

Induction coil equipment, which has predominated in ignition systems to date, has proved relatively satisfactory, but has been overtaxed by the need for dependable performance under conditions of wide primary voltage variation. This arises as the result of heavy starting motor load on the electrical system during static starts as opposed to no starting motor load during windmilling starts in flight. This particular problem has been fairly well solved, however, by redesign of the coils. New ignition system elements may improve reliability still further.

The second source of troubles, in order of frequency, is the fuel and power control system, with a score of 24 per cent. Numerous factors determine optimum operation of the turbojet. This, together with the large fuel requirements of the engine, renders it necessary that the power regulating device be capable of automatic compensation for all factors so that preflight check running is held to a minimum and in-flight manipulation is accomplished by a single power-scheduling control. To do this, it is necessary for the control to regulate fuel flow automatically, subject to airflow, r.p.m., tailpipe temperature, and throttle position. It must sense changes in airflow resulting from altitude, attitude, air speed, temperature, etc., and for a given throttle setting maintain a constant percentage of full available power. In nonvariable exhaust orifice engines, this is approximately analogous to constant r.p.m. In variable exhaust area engines, it is analogous to constant r.p.m. and tailpipe temperature.

The fuel system is required to provide large, closely metered flows at high pressure. Service experience indicates that, where close tolerances are used, micronic filtering is essential to eliminate foreign material originating in fuel handling prior to delivery to the aircraft.

The lubrication system, with a frequency of 4 per cent, demonstrates an outstanding advantage of the present jet engine as compared with the reciprocating engine. The piston engine has several times as many moving parts *per cylinder* than are found in the whole basic jet. In the turbojet engine the main rotating element is carried in something less than half-a-dozen bearings, with some designs having no more than two. The result is relative simplicity of lubrication flow paths; hence, less trouble.

In the chart, Fig. 3, some of the lube system trouble represented resulted from installation deficiencies, such as lack of provision in the airplane oil tank against interruption of oil supply during maneuvers. The high rotative speeds encountered in jet engines render the bearings extremely sensitive to discontinuous oil flow, since centrifugal force rapidly dissipates oil film within the bearing, especially in antifriction-type bearings. Added to this is the fact that the pump elements require a period of time to reprime, which can be critical. This problem has been solved by suitable changes in oil reservoir and pumps.

A related condition has existed in the fuel system whereby, when tanks were permitted to run dry, the main fuel pump became air bound and it was impossible to restart the engines in flight. This, too, was traced to its source and corrected. At the same time, operating procedures were improved to avoid unanticipated exhaustion of tanks.

Overhaul and Maintenance

The official overhaul period for the J30 engine is 150 hours. After approximately 22 months of service use, a goodly proportion of the engines are turning in full time between overhauls. During these early stages, it was deemed wise to have frequent inspections. It is encouraging that the majority of the checks are passed without adjustment, indicating that it should be possible to relax some of the requirements.

Field operation has emphasized that a proper starting procedure is one of the most critical factors in obtaining good jet engine life. More damage can be done by one hot start than by hours of high-power operation, especially at altitude, where r.p.m. is the limiting factor rather than tailpipe temperature.

In discussing overhaul periods in turbojets, it must be borne in mind that usefulness should be measured in terms of flight pay-load miles rather than in terms of operating hours. There is no justification for applying turbojets to aircraft other than those in the high-speed categories (in terms of present-day practice), since this type of power plant is uneconomical operationally under any other circumstances. The pay-load miles turned in by a 300–400-hour turbojet with average true flight speed of 450–550 m.p.h. will show up favorably in comparison with the reciprocating engine performance at present air speeds and overhauls. That longer overhaul periods, without replacement of basic engine parts, are entirely feasible is being proved by endurance testing on newer types of engines. Where long life is of paramount importance, as in commercial aircraft, even longer service can be obtained by a different design balance between engine life and performance.

In this connection, there should be noted the necessity for major improvement in air traffic control before the turbojet can be exploited to best advantage in com-

mercial applications. Taxiing, waiting, and milling must all be reduced to near the vanishing point. This is true because all such operations consume fuel at a rate out of all proportion to value. As the turbojet grows larger, approaching sizes and efficiencies compatible with commercial application, it may require somewhat more preflight check and warm-up than it does in its present form, but it will always be, basically, a fast starting and prompt take-off engine. By the same token, this is the only way to realize its inherent qualities to best advantage. It seems entirely likely that, even with the best airport traffic control, the logical method for ground handling of jet-powered aircraft will be by auxiliary power—that is, towed by tractor to take-off point and picked up by the same means from the point of landing stop. One can even go a step farther and visualize a detachable taxiing power unit that is controlled from the airplane itself, just as its own power plants would be. All of this ties in with the principal virtue of the jet—high speed. Boosted block speeds—even with added comfort of smoother operation—will be of secondary value to commercial interests if airport maneuvering and waiting time is not almost entirely eliminated. Even transcontinental trips of 6 hours or so are not too impressive if, frequently, an additional 20 min. to $^1/_2$ hour is spent actually getting air-borne after loading, not to mention serious time losses due to waiting for landing clearance, etc.—all this in addition to an hour or two getting to and from terminals.

All of these elements must be carefully considered in evaluating turbojet usage. However, with proper application, it bids fair to be a more economical commercial engine, in that its pay-load miles per overhaul will be much higher, yet its economy of operation will be entirely within reason by virtue of using, to maximum advantage, its speed and altitude characteristics.

Conclusions

As is evident from the foregoing, auxiliary engine components contribute a major proportion of operating troubles in the field.

As requirements increase, turbojet engines and particularly accessories are likely to become more complex. Hence, unless a special effort is made it may be expected that accessory troubles will further increase. This has led the authors to the following conclusions.

Engine Builders

The engine builder faces rapidly increasing requirements on engine performance and operation. If these requirements improve the overall utility of the engine and increase the pilot's safety, it is up to the engine builder to lean over backwards to fulfill these requirements in the simplest possible manner, without gadgetry and without compounding safety features. A real effort will be involved to maintain the inherent simplicity and reliability of the turbojet engine.

Accessory Builders

Gaskets that leak, valves that stick, bushings that wear, etc., have been the most frequent and the most irritating source of field troubles. Accessories will be required to have a degree of reliability beyond what has been the practice in the past. The accessory builder shoulders a real responsibility. To make it possible for him to carry out his task, he and the engine builder should cooperate closely so that the requirements can be established at an early date.

New designs must be simple and reliable, free from troublesome features that have shown up in the past. Manufacturing procedures and quality control should be such to ensure that the parts will do what is intended

Users of Engines

The users of engines—meaning the services, the airplane builders, and later on the air-line operators—who set the pace for engine requirements, would do well to make an operational and economic survey to determine how much further performance and safety requirements should be carried. It is conceivable that a point may be reached in which safety features are compounded to such an extent as to give only imaginary protection because of troubles occurring within the protective equipment itself.

The authors are of the opinion that the following recognized considerations are promising, particularly from the standpoint of maintenance:

(a) In view of the fact that near-sonic flight involves engine features not necessary for engines that operate at lower speeds and in view of the fact that it is particularly in the engines for lower flight speed that fuel economy will be paramount, it may be well to develop two kinds of jet engines, using, if necessary, some of the same or similar main components. The engine directed primarily toward ultrahigh flight speeds for interceptor types would be designed for reasonable fuel consumption, light weight, and a relatively short life. It would contain those operational features necessary for flying at supersonic speeds. The low-speed engine, designed for long range, would excel by low fuel consumption for long-range operation. It would be heavier and built for extended operation but would not need those features involved for ultrahigh flight speeds.

(b) Instead of increasing the number of power drive pads from the engine, it may, under certain circumstances, be preferable to either supply a separate gear box for aircraft accessories or to combine some of the accessory functions in such a manner that they can be accomplished in a single unit instead of in various separate accessories each with their own drive.

This can be carried one step further in the interest of maximum availability, by way of complete divorcement of the auxiliary services from the engine itself, operating these from another power source. This might lend itself to optimum maintenance accessibility of both en-

(*Continued on page 77*)

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Analysis of Eccentrically Loaded Riveted or Bolted Joints

By

G. M. Monroe

U.S. Navy

The semigraphical analysis developed here is applicable to all riveted or bolted joints not stressed beyond the elastic limit. The stress on each rivet or bolt is obtained by plotting one point on a scale drawing of the joint and multiplying the distance from this point to each rivet or bolt by a constant factor. The coordinates of the point and the multiplying factor depend only on the loads on the joint, the total rivet area, and the polar moment of inertia of the rivet areas. The application of this method is simple and brief.

Principles of Structural Design for Minimum Weight

By

F. R. Shanley

The Rand Corporation and University of California

The usual procedure in structural analysis involves the determination of the strength of a certain structure under specified loading conditions. From the design point of view the real problem is to determine the lightest practical arrangement of material which will transmit the required loads through the specified distances. This may be accomplished through the use of the structural index. The engineering significance of this index and its applications to design problems are discussed. Examples include the tubular column, stiffened flat plate under axial load, the unstiffened plate with edge support, shear-carrying members, and cylindrical shells in bending. Methods of comparing various materials on a weight basis are developed and applied to several aluminum alloys, magnesium alloy, and stainless steel.

Wind-Tunnel Wall Corrections for Wing-Body Combinations

By

C. B. Smith

United Aircraft Corporation

The image system required to satisfy the boundary conditions for a wing-body combination in a closed circular tunnel is deduced, and the upwash interference due to the tunnel wall is thereby calculated. The development starts from first principles and utilizes elementary methods. An incompressible nonviscous fluid is assumed. The results indicate an interference significantly different from that obtained for the wing alone. In particular, it is found that the magnitude of the interference for the wing-body combination may be up to twice as great as for the wing, and in all cases the distribution along the wing span of the tunnel-induced upwash is opposite to that for the wing alone (tends to produce a root rather than a tip stall). It is concluded that wing-alone corrections are not, in general, applicable to wing-body combinations.

Please do not order Preprints of these papers at this time.

See pages 50 and 51 for Preprints that are immediately available.

The Theory of Beam Columns with Continuous Support Applied to the Problem of Stringer Roll

By

G. C. Best

Consolidated Vultee Aircraft Corporation

In this paper the theory of beam columns of constant section with continuous support is developed, the mathematical procedures following those already laid down by Timoshenko and other writers. All deflections are considered to be within the proportional limit. Only the case of a moment at one end is considered, the principle of superposition then permitting its extension to the case of a moment at each end. Buckling loads are obtained from the criterion that moments become infinite. Results are applied to the problem of stringer roll by considering the vertical portion of the stringer as supplying continuous support to the flange, which is considered as a beam column. An example is worked out.

The Potential Flow Around Given Wing Sections

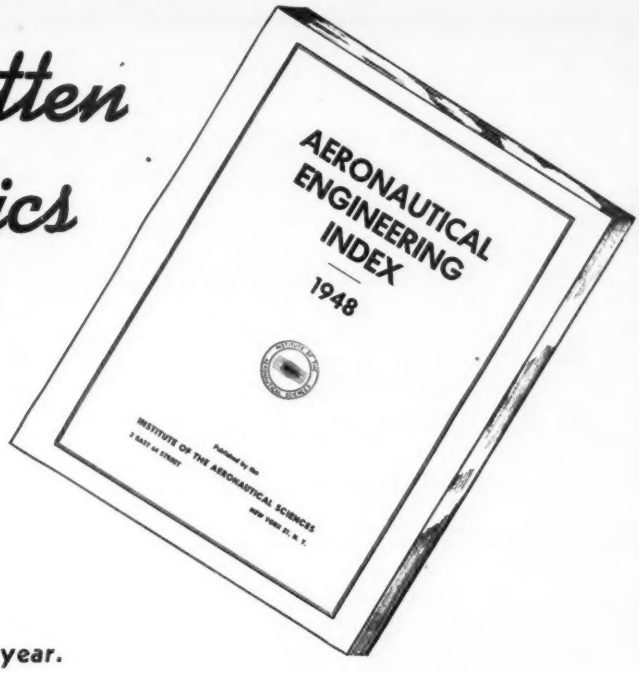
By

Kwei-Lien Chang

Bureau of Aircraft Industry, China

By the use of Wilton-Morris' parametric representation and the von Kármán-Trefftz transformation, the complex potential around a given wing section can be given as an exponential series. This series is exact in the sense that the actual profile instead of the approximate one is used for its development.

What was written on Aeronautics in 1948?



Here are the answers— in one handy reference guide. Over 5,000 abstracts and listings of important technical articles and books published during the year.

Each month, over 800 periodicals, reports, books, and house organs pertaining to the aeronautical sciences are screened, listed, and digested by the Institute's editorial and library staffs. The AERONAUTICAL ENGINEERING INDEX is the end-product of this year-long effort. In this concisely indexed volume will be found listings and abstracts of those items deemed of interest and importance to engineers and scientists in all branches of aeronautics.

INDEX FOR 1947

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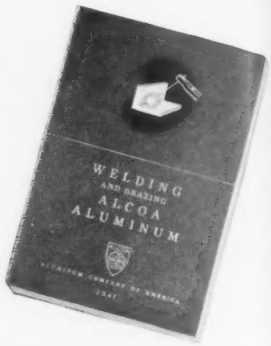

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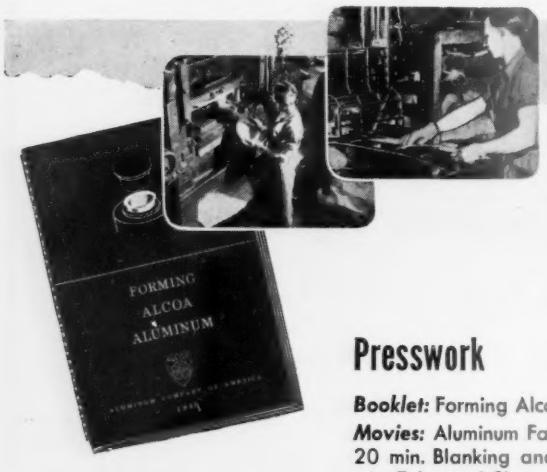

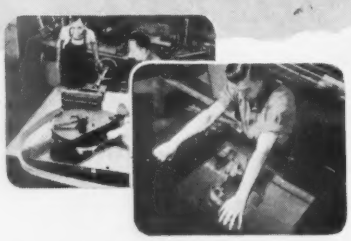

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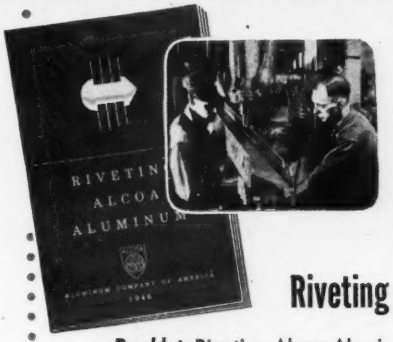

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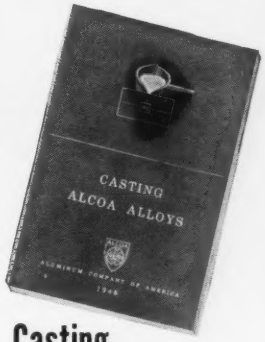

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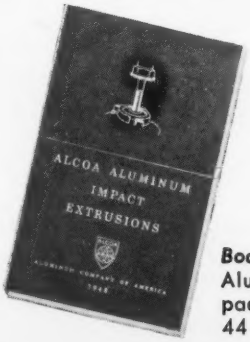

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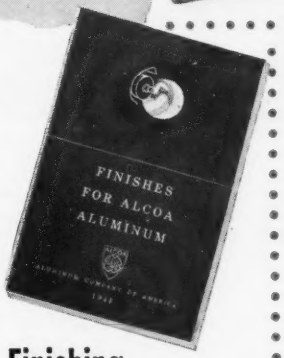

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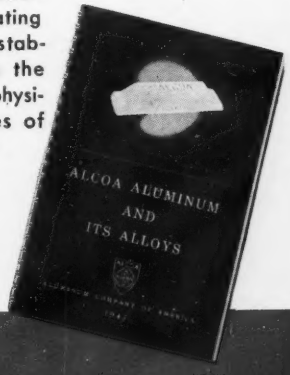

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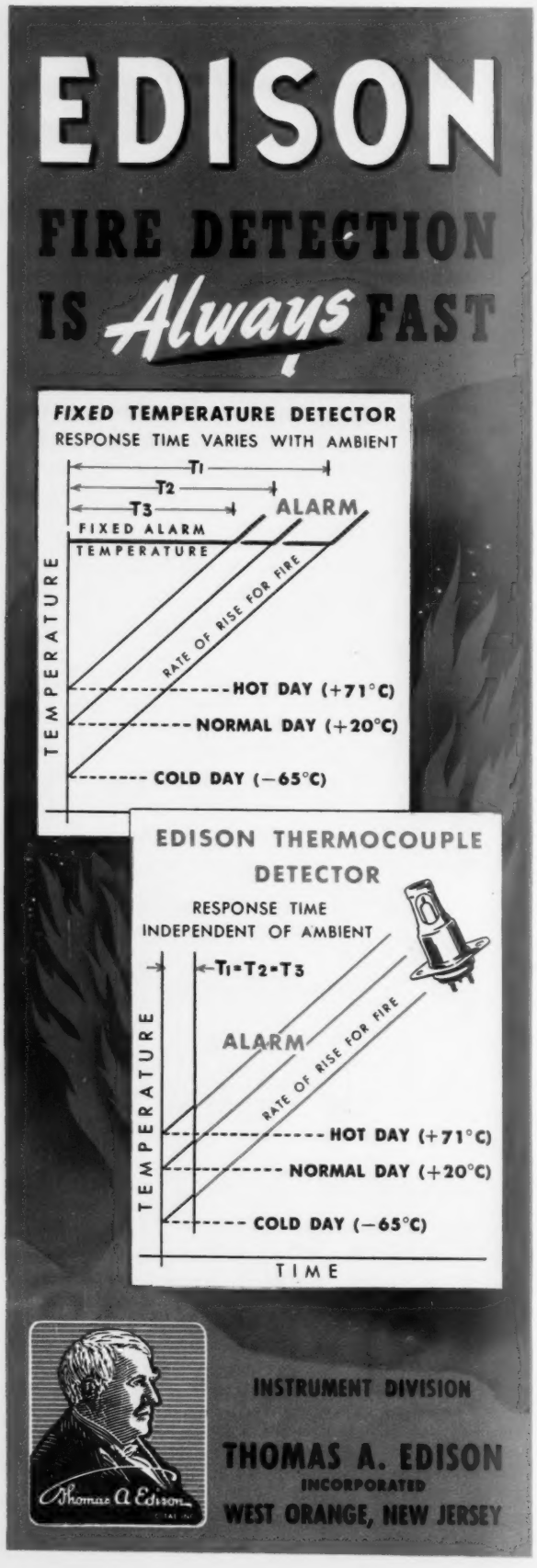

Aerodynamics (2)

AERODYNAMIC LOADS

Flight Measurements of Buffeting Tail Loads. Allen R. Stokke and William S. Aiken, Jr. *U.S., N.A.C.A., Technical Note No. 1719*, October, 1948. 19 pp., diagrs., figs. 5 references.

Magnitudes and frequencies of buffeting tail loads were measured on a fighter-type airplane up to Mach Numbers of about 0.80. The buffeting tail-load increment for a constant dynamic pressure decreased with increasing Mach Number. Critical combinations of buffeting and maneuvering tail loads that are above the limit load and approach the design load for the horizontal stabilizer may occur in low-altitude, low-speed flight with rearward centers of gravity at the limit design acceleration.

BOUNDARY LAYER

The Boundary Layer of Yawed Infinite Wings. J. M. Wild. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 41–45, figs. 8 references.

An approximate solution to the boundary-layer equations for an infinite yawed cylinder is obtained by an extension of the von Kármán-Pohlhausen method. From this solution the direction of the flow in the boundary layer and the displacement and momentum thicknesses of the spanwise flow component may be calculated. To illustrate this method, the boundary layer over a yawed infinite wing at a lift coefficient just below the stall is calculated. Typical results are presented graphically. A strong spanwise flow is found which is in qualitative agreement with experimental observations.

CONTROL SURFACES

Linearized Theory of Supersonic Control Surfaces. P. A. Lagerstrom and Martha E. Graham. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 31–34, figs. 6 references.

A development, according to linearized theory, of the aerodynamic theory of control surfaces in supersonic flight. The pressure distribution is calculated which is induced by the deflection of trapezoidal or triangular control surfaces attached to an immovable wing so as to produce mutual interference between the wing and the control surface. From the pressure distribution the lift and center of pressure are found. In general, only a small part of the wing is influenced by the deflection of the control surface. Hence, the control surface itself carries most of the aerodynamic load. In the cases under consideration, the total lift on the wing and on the control surface induced by deflection is greater than the total lift obtained by the same deflection of an isolated control surface, because the mutual dependence of the upper and lower surfaces near a subsonic edge is prevented by the presence of the wing. Linearized theory does not take into account the viscous properties of a fluid which might cause loss of lift, particularly leakage through the gap between the wing and the deflected surface. Such leakage could provide some communication between the upper and lower surfaces. In general, although linearized theory gives a fair prediction of the lift and the wave drag of a wing, the values it gives for control surfaces are expected to be too high.

Flight Investigation of a Combined Geared Unbalancing-Tab and Servotab Control System as Used with an All-Movable Horizontal Tail. Robert G. Mungall. *U.S., N.A.C.A., Technical Note No. 1763*, December, 1948. 16 pp., diagrs., figs. 4 references.

Contains data from a flight investigation of an all-movable horizontal tail having a combination of geared unbalancing tabs and servotabs fitted on a Curtiss XP-42 airplane. Longitudinal control characteristics were investigated. The results indicated that a control system of the type tested could be expected to give a value of force per g independent of either altitude or c.g. position and yet provide satisfactory control-force feel for rapid maneuvers.

FLUID MECHANICS & AERODYNAMIC THEORY

Formation and Decay of Shock Waves. K. O. Friedrichs. *Communications on Applied Mathematics*, Vol. 1, No. 3, September, 1948, pp. 211–245, figs. 7 references.

A simplification of the method of finite differences for determining, with good approximation, the interaction of weak or medium-strength shocks in continuous gas flow. Terms of higher than second order in shock strength and change in entropy across the shock front are disregarded. By appropriately modifying the conservation laws across the shock, the "back reaction" of the shock on the wave behind is disregarded, and it becomes possible to determine the wave motion behind the shock front independently of the shock. The course of the shock can be determined afterwards by solving a simpler linear differential equation. The method is applied to one-dimensional flow to find the shock path and a formula for the development of shock strength. The width of the wave zone following a decaying shock increases as the square root of the time, and the strength of the shock decreases as the reciprocal of the square root of the time. An expression is obtained for the width of the wave zone in an "N-wave." The method can be used to examine the formation of a shock in the interior of a compression wave such as that produced by a piston when pushed into a gas with increasing acceleration beginning with the acceleration zero. The approximation method is applied also to two-dimensional steady flow in a study of the fading out of the shocks that develop at the leading and trailing edges of a two-dimensional airfoil in a supersonic air stream. The separation between the leading-edge shock front and the Mach line issuing from the peak of the profile increases as the square root of a distance measured normal to an axis with its origin at the leading edge of the airfoil and coinciding with the direction of the free stream. The strength of the shock decreases inversely as the square root of this distance.

On the Non-Occurence of a Limiting Line in Transonic Flow. Appendix. Donald A. Flanders. *Communications on Applied Mathematics*, Vol. 1, No. 3, September, 1948, pp. 287–301. 12 references.

A mathematical investigation of the hodograph representation of the flow past an airfoil or through a duct, when the Mach Number of the free stream is less than unity but supersonic flow exists within some limited region adjacent to the profile or wall of the duct. It is shown that, if the analytic functions of the velocity components of the two-dimensional flow which satisfy the appropriate differential equations and boundary conditions depend continuously on the Mach Number in such a manner that the Jacobian does not vanish when the free-stream velocity is less than unity, then the Jacobian does not vanish when the free stream has a velocity equal or greater than $M = 1$. Since the limiting line is the image of the curve along which the Jacobian vanishes, no limiting line can occur in the type of transonic flow under discussion.

Decaying Shocks; A Comparison of an Approximate Analytic Solution with a Finite Difference Method. Anneli Lax. *Communications on Applied Mathematics*, Vol. 1, No. 3, September, 1948, pp. 247–257, figs. (Cf. preceding abstract.)

An investigation of the accuracy of the approximate analytical method of K. O. Friedrichs for determining the behavior of decaying shock waves. In order to test its validity for shock waves of varying strength by comparison with a finite-difference scheme that is limited in its applicability to shocks of any strength only by the size of the mesh used, both methods are applied to a corresponding problem for surface waves in shallow water. The shock strengths treated—i.e., the ratio of the height of the moving water to the height of the still water—are: 1.2, 1.5, 1.8, and 3.0. The results show good agreement between the two methods for all cases, even for the ratio 3.0, which is a stronger shock than those usually classed as weak shocks.

Problems and Progress in Low-Pressures Research. E. D. Kane and R. G. Folsom. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 46–54, illus., diagrs., figs. 8 references.

A review of the experimental problems encountered in the study of the dynamics of rarefied gases. Because of the considerable response time of the McLeod gage when it is constructed for the low-pressure range, a precision U-tube manometer filled with butyl phthalate mixed with low vapor pressure oil is used for pressures from 0.6 to 6 mm. Hg. The Pirain gage can be used in the pressure range of 1 to 55 microns Hg. An oxygen absorption flow-visualization system has been developed which uses a hot-cathode discharge tube with a xenon atmosphere to produce light of the required 1,470Å wave length. Low-pressure supersonic-flow continuous-operating open and closed-throat nonreturn wind tunnels are under development at the University of California. Preliminary results obtained in a 1- by $^3/_8$-in. cross section at a pressure of 1 in. abs. and $M = 2.4$ have confirmed the existence of the large viscous effects predicted by theory and possibly have shown the slip at the boundary.

On the Solution of the Boltzmann Equation for Rarefied Gases. Joseph B. Keller. *Communications on Applied Mathematics*, Vol. 1, No. 3, September, 1948, pp. 275–284. 5 references.

When the Boltzmann integrodifferential equation for the distribution function of a gas is handled by Jaffe's method, a power series is obtained in which each coefficient can be determined uniquely for general initial and boundary conditions. Hence, if the series converges, a solution of the equation exists. The existence and uniqueness theorem for the coefficients is extended to include problems of simple geometry, which may be introduced into the boundary conditions for the distribution function by a solid or liquid surface. The first approximation for the drag of a moving body in a gas, with mean free path large in comparison with the dimensions of the body, agrees with the results obtained by Heineman by another method. The first approximation of the density and velocity of a gas in free expansion compares well with exact solutions of the equations of gas dynamics and shows that the escape speed of the gas and the rate of propagation of the rarefaction do not equal the speed of sound.

Theory of Drag in Highly Rarefied Gases. M. Heineman. *Communications on Applied Mathematics*, Vol. 1, No. 3, September, 1948, pp. 259–273, figs. 8 references.

General formulas are obtained for the drag on a convex body of any shape in free molecular flow under conditions of specular and diffuse reflection. The drag coefficient is plotted against the Mach Number for the following special cases: a plate at any angle of attack, a sphere, a cylinder, a cone, and an ellipsoid. These are first approximations, in which the effect of the collisions of the reflected molecules on the velocity distribution in the neighborhood of the object is considered to be inconsequential. A second approximation is developed in which the collisions of those molecules that collide once in the gas before striking the object are taken into account. Numerical results for this second approximation have been obtained only for a plate moving in a direction perpendicular to its plane at very high Mach Numbers.

The Decay of Isotropic Turbulence. F. N. Frenkiel. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 311–321, figs. 19 references.

The equation of decay of isotropic turbulence is determined in the two cases of large and small Reynolds Number of turbulence by using the von Kármán-Howarth equations and applying Loitsianskii's theorem of the conservation of the disturbance moment. The theoretical curves are compared with the results of measurements behind grids made by various experiments in the United States and in England. The decay of the longitudinal turbulent energy seems to agree well with the theoretical equations for large Reynolds Number of turbulence. The theory does not give the variation of the transverse scale of turbulence measured in the experiments but only the "disturbance length," which is a function of the longitudinal correlation. Thus, the comparison for the scale is only qualitative. It is not possible to show agreement with the theoretical variation of the scale deduced from the equations. The difference is explained by the imperfect isotropy, which has a much greater influence on the variation of the scale than it has on the energy decay. The present comparison of the theory with the experiments differs from similar prior comparisons by the fact that the decay is given as a function of the initial conditions of the turbulence at a chosen moment without using arbitrary constants.

The Effective "Gamma" for Isentropic Expansions of Real Gases. Arthur S. Iberall. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 997–999.

In an isentropic expansion of a real gas, the relationship $pv^{\gamma} = C$ (γ, C constant) is not exact. A development is given for an accurate exponent $\bar{a}$ (the effective "gamma"), related to the ratio of specific heats, which permits the use of the relationship $p_0 v_0^{\bar{a}} = p_1 v_1^{\bar{a}}$ for an isentropic expansion between any two pressures. The exponent may be computed from the initial conditions of the gas, the expansion ratio, equation of state data, and data on the variation of specific heat with temperature.

Letters to the Editor: On the Flow of a Perfect Fluid Between Two Plates From a Circular Inlet Channel. E. T. Benedikt. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 1094, 1095, fig. 2 references.

INTERNAL FLOW

Linearized Treatment of Supersonic Flow Through Ducts. H. F. Ludloff and F. Reiche. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1948, pp. 5–21, figs. 7 references.

Linearized theory is used to obtain analytical expressions for the velocity and pressure fields that occur in supersonic flow through ducts. Supersonic sources of various intensities are assumed to obtain over the surface of a skeleton cylinder, and expressions are obtained for the velocity and the stream function. A solution is also included for the case in which the source intensity increases linearly along the generatrices of the cylinder. Combinations of these two cases afford the greatest generality and have the most validity for this kind of treatment of internal flow. From these solutions, nozzle shapes can be obtained in which the throat may be adjusted at will. A general theorem is established for the velocity field of any arbitrary source distribution. The pressure distribution calculated for the interior of ducts shows the compression and expansion waves that exist at the surface of the entrance Mach cone and at the extension of this surface, which is called the "second Mach cone." In general, the intensity of these waves is small, and the distance between them is appreciable. The rim of the duct, however, can be designed to produce a compression wave followed immediately by an expansion wave. As the interval between the waves decreases, their intensities approach infinity. The form of the wave front has been computed to a second approximation. For small lip angles, the wave shape differs only slightly from that of a double cone. This result is in qualitative agreement with Ferri's analysis.

Investigations of the Flow in Curved Ducts at Large Reynolds Numbers. J. R. Weske. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 344–348, diagr., figs. 6 references.

The flow in curved ducts at high Reynolds Numbers may be analyzed by methods adapted from the theory of boundary layers. Integration of the equation of motion of the "shedding layer" leads to relations for the net pressure drop of curved ducts as a function of radius ratio and of Reynolds Number.

A Method of Correlating Axial-Flow-Compressor Cascade Data. Hunt Davis. *American Society of Mechanical Engineers, Transactions*, Vol. 70, No. 8, November, 1948, pp. 951–955, diagrs., figs. 2 references.

The results of tests on about 40 different cascades of NACA four-digit profiles at low Mach Numbers with a Reynolds Number of about 2×10^5 were plotted with the cotangent of the entrance angle of flow as a function of the outlet angle of flow. Two charts were developed which relate the camber, solidity, and stagger of the cascade and the entrance angle and the turning angle of the flow. When any four of these variables are given, the fifth may easily be found, and thus an appropriate cascade may be selected to match a set of predetermined velocity diagrams. By Eckert's use of the Prandtl correction, the applicability of the charts may be extended to subsonic Mach Numbers above 0.4. All profiles in the cascade must belong to the same family, and for each family, a separate chart must be constructed.

Flow of a Compressible Fluid Through a Series of Identical Orifices. C. S. L. Robinson. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 308–310, figs. 5 references.

A method for computing the weight flow of a gas or vapor through a number of like orifices. It is based upon the general equation for a single orifice and upon certain reasonable assumptions. There are included curves showing the influence of the number of orifices. For expansions beyond the overall critical-pressure ratio, the effect of each additional orifice is increasingly reduced. For example, increasing the number of like orifices from six to seven will decrease the flow only about 5 per cent. Two applications of this study are suggested—i.e., to multiple-orifice devices for heat-exchange equipment and to labyrinth packing for shaft seals.

The "Coanda Effect." R. S. Sproule and S. T. Robinson. *Combined Intelligence Objectives Sub-Committee, Item No. 5, File No. 9-1, 10-2, 12-1.* 28 pp., figs. British Information Services, New York.

Description of inventions of Henri Coanda which employ a fluid expelled from a slot over a diverging lip. A nozzle was designed for an engine-cooling system in which the slot and lip were placed upstream of the constriction of a nozzle and were so designed that the engine exhaust was turned into the nozzle. The volume of cooling air thus entrained was 20 times the volume of exhaust gas. The principle has also been used in a rotary pump that has produced a 99.8 per cent vacuum at an efficiency of 98 per cent, and it has been suggested for the propulsion of streamlined bodies. By turning the flow over the exterior surface of the body, the increased velocity of the boundary layer would produce low pressure and consequent lift, and the ejected fluid would supply jet thrust.

STABILITY & CONTROL

Influence of Tail Length Upon the Spin-Recovery Characteristics of a Trainer-Type-Airplane Model. Walter J. Klinar and Thomas L. Snyder. *U.S., N.A.C.A., Technical Note No. 1764*, December, 1948. 17 pp., illus., diagrs., figs. 4 references.

The model was tested in the Langley 20-ft. free-spinning tunnel with two tail lengths. Both tail lengths were tested at essentially the same loading condition. The results indicated that the recovery characteristics of an airplane may be influenced by the airplane tail length to a greater extent than is indicated by the value of the tail-damping power factor.

Flight Tests of an Apparatus for Varying Dihedral Effect in Flight. William M. Kauffman, Allan Smith, Charles J. Liddell, Jr., and George E. Cooper. *U.S., N.A.C.A., Technical Note No. 1788*, December, 1948. 35 pp., illus., diagrs., figs. 4 references.

Stick-fixed effective-dihedral angles ranging from 14.9° to −2.7° were satisfactorily simulated under static and dynamic conditions. Simulation of an even wider range of dihedral appears possible with this apparatus for a restricted range of sideslip angles.

Effects of Antispin Fillets and Dorsal Fins on the Spin and Recovery Characteristics of Airplanes as Determined From Free-Spinning-Tunnel Tests. Lawrence J. Gale and Ira P. Jones, Jr. *U.S., N.A.C.A., Technical Note No. 1779*, December, 1948. 21 pp., diagrs., figs. 2 references.

The effects of antispin fillets and dorsal fins on the spin and recovery characteristics of airplanes were determined from an analysis of the results of spinning investigations of a large number of models tested in the Langley 15-ft. and 20-ft. free-spinning tunnels. The action of antispin fillets is to make the fuselage area below them more effective in damping the spin rotation. Dorsal fins affected spin and recovery characteristics very little.

Readers' Forum: Determination of Stability Derivatives From Flight Data. Harry Greenberg. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, p. 62.

THERMO-AERODYNAMICS

Ram Temperature—Supersonic Speed Barrier. *Aero Digest*, Vol. 57, No. 5, November, 1948, pp. 26, 104, illus.

A graph of the variation in ram-air temperature with both altitude and flight velocity, which shows the increasing aerodynamic heating effect to which aircraft will be subjected as they are designed for higher speeds. Graph was drawn up by AiResearch Manufacturing Company.

WINGS & AIRFOILS

Two-Dimensional Airfoils in Hypersonic Flows. Richard D. Linell. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 22–30, figs. 4 references.

Equations for the force and moment coefficients of a sharp-edged two-dimensional airfoil are developed on the basis of Tsien's hypersonic similarity law. The coefficients are calculated for a flat plate and for three airfoils with thickness. The optimum airfoil is a wedge whose lower surface is flat, with the maximum thickness at mid-chord. The results are valid when the product of the Mach Number and the thickness ratio is of the order of 1.

Airfoils in Slightly Supersonic Flow. Hsue-Shen Tsien and Judson R. Baron. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 55–61, 64, figs. 4 references.

An investigation to determine the performance of simple thin airfoils in the slightly supersonic flow region with the aid of the nonlinear transonic theory first developed by von Kármán. Expressions for the pressure coefficient across an oblique shock and a Prandtl-Meyer expansion are developed in terms of a transonic similarity parameter. Aerodynamic coefficients are calculated in similarity form for the flat plate, and asymmetric wedge and curves are plotted on the usual coordinate grid of C_l, C_d, and

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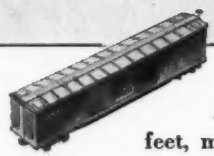

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$Cm_{c/4}$ versus angle of attack and C_l versus Mach Number to illustrate the apparent features of nonlinear flow.

Theoretical Basic Span Loading Characteristics of Wings with Arbitrary Sweep, Aspect Ratio, and Taper Ratio. Victor I. Stevens. *U.S., N.A.C.A., Technical Note No. 1772*, December, 1948. 33 pp., diagr., figs. 3 references.

A procedure based upon the Weissinger method is presented so that the basic span loading, the angle of zero lift, and the pitching moment due to twist can be readily predicted for a wide range of plan forms. To establish the effects of sweep, aspect ratio, and taper ratio on the basic loading characteristics, the method is applied to a few representative wings having uniform twist.

Charts for the Conical Part of the Downwash Field of Swept Wings at Supersonic Speeds. Jack N. Nielsen and Edward W. Perkins. *U.S., N.A.C.A., Technical Note No. 1780*, December, 1948. 32 pp., figs. 7 references.

Analytical expressions have been derived for the down-wash throughout the entire induced flow field of lifting triangles of infinite chord with the leading edges either in front of or behind the Mach cone. Down-wash charts have been prepared from which the down-wash field may be determined for any practical combination of leading-edge sweep angle and flight Mach Number. These charts for the lifting triangle of infinite chord are basic to the solution for the down-wash field of any finite swept wing wherein the contributions of the tips and trailing edges are to be determined by the method of lift cancellation as employed by Lagerstrom and others.

General Theory of Airfoil Sections Having Arbitrary Shape or Pressure Distribution. H. Julian Allen. *U.S., N.A.C.A., Report No. 833*, 1945. 23 pp., figs., tables. 12 references. U. S. Govt. Printing Office, Washington. $0.20.

Airplane Design & Description (10)

Psychological Aspects of Stick and Rudder Controls in Aircraft. Jesse Orlansky. *Aeronautical Engineering Review*, Vol. 8, No. 1, January, 1949, pp. 22–31, diagrs., figs. 30 references.

A study of the pressure cues given by the stick and rudder to determine in what manner control design can supply optimal sensory information. Published literature and extensive interviews with jet-plane pilots show that current force specification limits are generally lower than the maximum that the pilot can exert. Increments of stick pressure in response to changes in stick displacement or speed should be geometric in order to furnish the maximum number of discriminable pressure cues. Best accuracy and consistency of performance are obtained when the work load is between 5 and 30 lbs. on the stick and between 15 and 60 lbs. on a wheel or rudder control. A desirable level of friction on hand controls is from 2 to 5 lbs. Conventional controls should be placed and shaped to facilitate gripping. Hand controls should be at elbow height and located symmetrically with respect to the pilot. The rate of control-stick motion appears to decrease as the load increases. Control force, with respect to control displacement at the beginning of a control movement, should provide good self-centering characteristics. In the range within which most maneuvering occurs, stick forces should be as slight as possible, and pilot sensitivity should be maximum. In order to warn the pilot as the limit of stick deflection is approached, the forces should peak. A plot of stick displacement vs. control force for various speeds should give a family of curves in which the curve providing the largest number of discriminable pressure steps covers the most important tactical requirements of the aircraft.

The Aérosudest SE-1010; Supplementary Photographs of the French Long-Range Survey Aeroplane. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, pp. 368, 369, illus.

Engineering Problems of a Small Pusher Design. Marvin Greenwood and Lomis Slaughter, Jr. *Aeronautical Engineering Review*, Vol. 8, No. 2, February, 1949, pp. 16–21, 33, illus., diagrs.

Detailed description of the design and structural details of the Anderson, Greenwood 14, an all-metal, two-place, pusher airplane powered by a Continental C-90 90-hp. air-cooled engine. A shoulder-high wing and a lowered instrument panel ensure a wide field of vision. The 9.6 aspect ratio of the wing was chosen to increase the ceiling and rate of climb and decrease the speed for maximum rate of climb. Its small area reduces gust loads, decreases drag, and improves cruising performance. At 100 m.p.h., the separation of flow on the upper wing, which is caused by wing-body interference, is restricted in the power-off condition to a small region at the wing-body junction by keeping to a minimum the convergence of the engine housing, the only part of the body projecting above the wing. The c.g. shift in the flight conditions is approximately 4.5 in. The engine is cooled by air inducted beneath the leading edge of the wing. Location of the cooling-air exhaust in the low-pressure area immediately ahead of the propeller provides ground cooling. The center and outer wing sections are of monospar construction with a light auxiliary rear spar. The spar in the center section and the leading edge constitute an integral 23-gal. fuel compartment.

Flying the Blackburn Firebrand (Mk. 5 Torpedo Fighter). R. G. Worcester. *The Aeroplane*, Vol. 75, No. 1954, November 19, 1948, pp. 646–648, illus., diagr.

An American All-Weather Naval Fighter (Douglas XF3D-1 Sky-Knight). A. Marthason. *The Aeroplane*, Vol. 75, No. 1953, November 12, 1948, p. 614, illus.

Primer (Fairey 2-Seat Trainer) Progress; Construction Begins at Hamble; Simplicity of Production. *Flight*, Vol. 54, No. 2083, December 25, 1948, pp. 619–621, illus., cutaway drawings.

Hawker: Britain's Fastest Plane (N.7/47 Carrier-Based Fighter). *Aviation Week*, Vol. 49, No. 20, November 15, 1948, p. 20, illus.

The Hawker Jet Fighters (P.1040 and N7/46). *The Aeroplane*, Vol. 75, No. 1956, December 3, 1948, pp. 701–703, illus. diagr.

Flying the Aerocar (Portsmouth). R. G. Worcester. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, pp. 730, 731, illus., diagr.

Italian Freighter (S.A.I.-Ambrosini P.512 Light Freighter). *Flight*, Vol. 54, No. 2081, November 11, 1948, p. 570, illus., diagr.

The Vickers Viscount (Transport). *The Aeroplane*, Vol. 75, No. 1955, November 26, 1948, pp. 673–677, illus., cutaway drawings.

New Piaggio and Caproni Designs; Some Details of Two Italian Light Twins (Piaggio 136 Amphibian and Caproni 193 5-Place Airplane). *Flight*, Vol. 54, No. 2086, December 16, 1948, p. 727, illus., diagrs.

Metallurgical Examination of Landing Wheel and Strut Wing Sections and Components From Japanese Aircraft "Frances." C. E. Huessner. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R. 1465*, March 15, 1945. 31 pp., figs. British Information Services, New York. $1.30. The "Frances" is a naval torpedo bomber, dive bomber, and reconnaissance airplane.

The Lesson of Foreign Aircraft. A. Francis Arcier. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 22, November 15, 1948, pp. 13, 14.

The design trends observed in captured German aircraft indicate that—by relaxing requirements of dimensional precision and using more adjustable fittings; by replacing bolts with rivets; by not cleaning raw materials before their fabrication; and by omitting unessential machining, finishing, plating, and polishing—the rate of production of military aircraft could be increased and their cost reduced.

Unconventional Design Loadings for Aircraft. Milton Jakosky. *Aero Digest*, Vol. 57, No. 5, November, 1948, pp. 58, 59, 105, 106, illus., diagrs.

Includes a list of 31 design criteria that, although not included in Fundamental Army, Navy, and C.A.B. specifications, may have to be taken into consideration in the designing of a structurally airworthy and servicable aircraft for particular operating conditions. Among these factors are stresses induced by relative deformation of heated and unheated portions of the structure, durability of the tail surface skin of aircraft operating from dusty and gritty runways, torsional load placed on the empennage by engine run-up vibration, rigging, ground handling, emergency landing conditions, and special maneuvering and gust loads.

A King's Flight; Its Aircraft, Crews and Duties on a Royal Tour. *Flight*, Vol. 54, No. 2084, December 2, 1948, pp. 657–659, illus., diagr.

Fighters. I—Some Considerations Affecting Design. II—Power Plant Installations, Present Day Armament. H. F. King. *Flight*, Vol. 54, Nos. 2080, 2081, November 4, 11, 1948, pp. 543–547; 571–575, illus., figs. (Extended summary of a paper.)

Development Problems in a New Aeroplane. G. R. Edwards. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, pp. 723, 724, figs. (Extended summary of a paper.)

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Development of a New Aircraft. I. II. G. R. Edwards. *Flight*, Vol. 54, Nos. 2085, 2086, December 9, 16, 1948, pp. 700, 701; 734–736; figs. (Extended summary of a paper: Problems in the Development of a New Airplane.)

Airports & Airways (39)

Traffic Control by Pictorial Situation Display. Loren F. Jones. *Aeronautical Engineering Review*, Vol. 8, No. 2, February, 1949, pp. 22–33, diagrs. 8 references.

Committee SC-31 of the Radio Technical Commission for Aeronautics has recommended that a common national system of air navigation and traffic control utilize pictorial situation display. Data for traffic control are to be obtained chiefly from ground radar equipment that obtains its responses from altitude-coded air-borne transponders. The displays will provide both ground and air-borne personnel with all the information necessary for traffic control. Teleran is based on this method of display and is sufficiently adaptable to be used with a rigid take-off and landing schedule, with a flexible schedule, and with nonscheduled aircraft. It can provide either fixed-block or moving-block traffic control. New traffic-control paths are established by drawing lines on the situation map being televised to the aircraft. Altitude stacking is replaced by lateral spacing, and adequate information is given to prevent collision with both equipped and unequipped aircraft. During the initial period of control, the final approach, taxiing on the ground, and takeoff, the pilot sees his aircraft represented as a spot moving on a map. The television-like diagrammatic display that is used in Teleran requires no ground computer, since the various displays originate from animated moving-picture films that are computed once and for all when the film is produced.

Flyability of the USAF Instrument Low Approach System (ILS) Compared with Low Approach Radar Control (GCA). James Castanias. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 22, November 15, 1948, pp. 10, 11.

Tests conducted by the All-Weather Flying Division, Air Materiel Command, showed that the GCA system was more precise in azimuth control than ILS but that the ILS system gave more precision in elevation control. Fewer abandoned approaches occurred with GCA than with ILS. B-17 aircraft showed the least precision in azimuthal control. C-47 aircraft showed the least precision in altitude control during GCA approaches. Type of aircraft was not a significant cause of deviations when ILS was used.

Air Field Control for Jet Airliners. Charles Gardner. *Indian Skyways*, Vol. 2, No. 9, September, 1948, pp. 31–33, illus.

Snow Removal; An Engineering Problem. Albert L. Edson. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 6–8, 10.

A discussion of the planning, training of personnel, equipment, removal technique, and cost of snow removal at Bedford State Airport during the winter of 1947–1948. A removal program should be planned in accordance with the wind direction and velocity predicted to follow the snowstorm and the cross-wind landing characteristics of the aircraft using the airport. The airport should be so laid out that well-drained spoil areas will be available adjacent to the areas to be cleared.

How to Cut Snow Removal Costs. Walter E. Betsworth. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 17, 41.

Snow Removal at Lansing. Neil G. Brackstone. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, p. 11, illus.

Snow Removal at Cedar Rapids. Frank F. Hidinger. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 22, 38, illus., diagr.

Fighting Snow at Mitchel Field. Ford Killen. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, p. 12, illus.

Snow Removal Survey. G. Silvering. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 13, 14, 16, illus.

An analysis of 68 replies to a questionnaire sent to airports in the snow belt of the U.S. Gives size of airport, snow-removal equipment by type, its use for other than snow-removal purposes, and comments on techniques and problems at individual airports.

Manufacturers' Equipment and Literature on Snow Removal and Ice Control. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 25–29, 41, illus. Forty items of snow-removal and -control equipment.

Gutter Type Runway Drainage Systems in Snow Areas. Wm. Cullinan, Jr. *Airports and Air Carriers*, Vol. 14, No. 5, November, 1948, pp. 18–21, 38, illus., diagrs.

Landing Lights for Helicopters; G.E.C. and B.E.A. Collaborate. *Modern Transport*, Vol. 60, No. 1548, November 27, 1948, p. 11, illus.

Airport Siting and the Weather. D. A. Davies. *The Aeroplane*, Vol. 75, No. 1955, November 26, 1948, pp. 680, 681, illus. (Extended summary of a paper: Meteorology in Relation to Airport Construction and Design.)

Airport Finance. *The Aeroplane*, Vol. 75, No. 1953, November 12, 1948, pp. 624–626, illus. An extended digest of Airport Economics (Preliminary Study) prepared by the Air Transport Bureau of the International Civil Aviation Organization.

Schiphol; The "Airport of the Netherlands." Roy Pearl. *Flight*, Vol. 54, No. 2085, December 9, 1948, pp. 689–693, illus.

Aviation Medicine (19)

High Altitude Hypoxia. Robert B. Lewis and Webb Haymaker. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 306–336, 354, figs., tables, 28 references.

The analysis of 75 deaths attributable to hypoxia at high altitudes which occurred during World War II includes the history of the flights during which the incidents took place, the causes of the hypoxic accidents, and the pathological changes. The changes were engorgement of systemic veins and marked passive congestion, edema, and hemorrhage of the internal organs; vacuolar changes with or without inclusions in cells of internal organs, especially the heart and liver; and reactive changes in leptomeningeal histiocytes, extravasation of lymphocytes into perivascular spaces of the brain, and acute ganglion cell changes in the brain.

The Recovery of the Brain From Anoxia After Administration of Analeptic Drugs. Werner K. Noell. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 337–345, figs. 7 references.

The Influence of Radial Acceleration (Centrifugal Force) on Respiration in Human Beings. Charles F. Lombard, Herman P. Roth, and Douglas R. Drury. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 355–364, illus., figs. 6 references.

The effects of centrifugal force applied positively (head to seat) and negatively (seat to head) upon respiration were studied on a human centrifuge of 25-ft. radius. Negative acceleration up to $-3g$ without protective gear caused slight increase in respiratory rate, a decrease in tidal volume, lung volume at end of expiration, and a decrease in vital capacity. Positive acceleration up to $+5g$ without a protective pneumatic suit or a tight belt produced a slight increase in respiratory rate, an increase in tidal volume, increase in the lung volume at end of expiration, and a decrease in vital capacity. Positive acceleration up to $+6g$ with a protective pneumatic suit showed moderate increase in respiratory rate, decrease in tidal volume, and decrease in lung volume at end of expiration. Positive acceleration up to $+5g$ with a tight abdominal belt gave a slight increase in respiratory rate which increased with g, slight increase in tidal volume, and slight increase in the lung volume at the end of expiration.

The Effect of Training and of Structural Aids on Performance in Three Tests of Space Orientation. H. A. Witkin. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 80*, October, 1948. 85 pp., illus., tables.

An investigation to determine the effect of training and of structural aids on performance in three space orientation tests, the Stability Orientation Test, the Dark-Room Test, and the Rotating-Room Test. Training of the subjects to give adequate weight to sensory data, other than visual, produced general improvement in orientation under the test situation in which the training was administered and also led to improvement in one situation that involved a different kind of orientation problem, the Dark-Room Test. Structural changes in the external situation to aid orientation produced significant improvement in orientation under the test conditions in which they were used. This improvement, however, was not transferred to other types of situation. When the task was to adjust the body to the upright, the group tested with structural aids did slightly better than the group that had received training. However, when the task was to adjust the visual field itself to the upright, training produced more improvement in performance than did the structural aids. Training ap-

parently produces a more valid interpretation of sensory data. Structural aids tend to alter the perceptions themselves and may constitute a more valuable aid to an individual than an improved sense facility.

Aviation Noise Deafness, Hearing Standards and Recruitment. W. J. Pothoven and A. Schuringa. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 380–388, figs. 15 references.

The recruitment phenomenon is an important factor in many cases of flying deafness. It is responsible for experienced fliers with a considerable hearing loss not having the slightest difficulty in performing their flying duties, although their hearing acuity does not come up to the standards. Hearing standards should be revised to take recruitment into account. Flying deafness can be prevented by using properly designed ear protectors to reduce the total noise level and by designing radio equipment to eliminate all frequencies not essential to the intelligibility of speech and signals.

Turbo-Jet Engine Noise. E. S. Mendelson, J. R. Poppen, A. T. Kornfield, and H. G. Wagner. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 365–374, figs.

A review of the research program conducted by the Aero-Medical Equipment Laboratory, Naval Air Experimental Station, Philadelphia, to determine the intensities and frequencies of the noises to which workers are subjected during operation of jet engines and the effects of this exposure on the human being. Sound-pressure vs. frequency curves have been obtained for the G-E I-16 in an open-end test cell, a TEC Supercharger, the British Rolls-Royce Nene-I, and the G-E TG 180-engine operated in a closed cell. Nine volunteer subjects were exposed, at various positions about a G-E I-16 engine, to the operating noise at 15,000 r.p.m. The findings of comprehensive physical and medical examinations after intermittent exposure over a period of 26 days were negative. The research program also included examination at 3-month intervals of individuals working in the jet-engine cells of the Naval Air Experimental Station.

Pilot Health: Accident Factor? *Aviation Week*, Vol. 49, November 15, 1948, pp. 38, 40.

Studies made by the British Flying Personnel Research Committee and the committee on aviation psychology of the National Research Council, the Franzen-Brimhall study, and the report of Dr. Brimhall of the C.A.A., all indicate that the aviation medical standards relating to flight personnel are not directly related to accident rates.

Possible Effects of Streptomycin Upon an Airman's Future. Paul A. Campbell. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 393–396. 11 references. A study of the deterioration of vestibular response produced by streptomycin and its possible effect on the performance of aircraft pilots.

International Quarantine and Air Travel. Charles H. Morhouse. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 389–392. 3 references.

Since international flights are well within the incubation period of all international quarantinable diseases, their control in air travel requires more effort than that used for any other method of transportation. The standards set by the convention of 1944 cannot be relaxed, and strictly sanitary airports for international travel must be maintained. The employees of such airports must be watched as closely as passengers, particularly with respect to a possible carrier status. The control of insect pests needs to be improved and health intelligence must be strengthened by making full use of modern communication systems.

Total Lung Volume and Maximal Breathing Capacity (MBC) in Pulmonary Emphysema After Repeated Periods of Intermittent Positive Pressure Breathing (IPPB). Hurley L. Motley, Leonard P. Lang, and Burgess Gordon. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 346–354, illus., diagrs. 8 references.

Engineering Materials, Design and Techniques of Investigation of Oxygen Equipment. L. W. Meakin, E. L. Hays, and J. R. Poppen. *Journal of Aviation Medicine*, Vol. 19, No. 5, October, 1948, pp. 375–379, 388, illus.

Examples of deformation, deterioration, and corrosion of breathing oxygen equipment during storage and a description of the qualification testing procedure for high-pressure oxygen-line valves. Proper selection of materials, simplicity of design, the matching of qualification tests with procurement specifications, and the coordination of qualification-testing techniques can reduce production and maintenance costs and increase the storage and service life of equipment.

Comfortization (23)

Speaking of Supersonic Flight. Gene May. *U.S., Air Services*, Vol. 33, No. 11, November, 1948, pp. 21, 22, 24. (An address.) A critique of the design of high-speed high-altitude research aircraft from the point of view of pilot comfort and convenience.

Turbine Cooler Unit. *Flight*, Vol. 54, No. 2081, November 11, 1948, pp. 576–578, diagrs., figs.

Design and operating characteristics of the Marshall air-cycle turbine cooler unit for airplane-cabin air-conditioning systems. The 54-lb.-per-min. unit weighs 21 lbs. It receives air from engine-driven blowers at a pressure of 6.5 lbs. per sq.in. into the eye of a single-sided centrifugal impeller. The air is overcompressed, delivered to an intercooler, and led to a turbine, from which it expands into the cabin ventilator ducts. The expansion of the air cools it and imparts energy to the turbine that drives the compressor.

Greater Comfort for the Airline Passenger. II—Seating. Kenneth R. Jackman. *Aero Digest*, Vol. 57, No. 5, November, 1948, pp. 42–46, 92, diagr., fig. 6 references. A summary of the anthropometric research that preceded the designing of seats for the Convair-Liner and descriptions of the laboratory programs, methods, and test devices.

Electronics (3)

Three-Dimensional Representation on Cathode-Ray Tubes. Carl Berkley. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 12, December, 1948, *Waves and Electrons Section*, pp. 1530–1535 diagrs., figs. 7 references.

A procedure for the representation of functions of a number of variables on the screen of a cathode-ray tube. The procedure may be applied to any regular system of coordinates or any number of variables. The representation may take the form of an oblique perspective picture. The procedure consists of the following steps: (1) setting the form of the representation, (2) deriving the position of the spot on the cathode-ray tube as a function of its true position in space, and (3) making the indicated corrections electrically. Applications in the fields of mathematics, radar, electromagnetic theory, mechanical measurements, topographic surveying, and meteorology are examined.

Radio Direction Finding Developments at 2nd Naval Research Laboratory, Japan. L. Ciacoletto. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./.P R/ 1223*, December 14, 1945. 4 pp. British Information Services, New York. $0.35. A tabulation of the characteristics of Japanese radio direction finders developed in the research program of the Japanese Navy.

The Absolute Calibration of Electro-Mechanical Pickups. Discussion. H. M. Trent. Albert London. R. S. Marvin, E. R. Fitzgerald, and J. D. Ferry. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 390–392, figs. 3 references.

Signal-to-Noise Ratio in AM Receivers. Eugene G. Fubini and Donald C. Johnson. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 12, December, 1948, pp. 1461–1466, diagr., figs. 4 references.

Engineering Practices & Aids (49)

Letter to the Editor: The Representation of Streamline Shapes. C. L. Kirste. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, p. 381, fig.

Equipment

ELECTRICAL (16)

Designing a Modern Electrical Installation; Some Features and Equipment of the Airspeed Ambassador: Planned Weight Reduction, 'Open' Cables, Self-Testing Indicator Lamps, Simplified Battery Installation. F. Brookesmith. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, pp. 373–375, illus., diagrs.

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HYDRAULIC & PNEUMATIC (20)

Industry Seeks Ideal No-Fire Hydraulics. Robert McLarren. *Aviation Week*, Vol. 49, No. 20, November 15, 1948, pp. 23, 24, 26. A summary of the progress made by the U.S. Government and industry groups in the development of a nonflammable hydraulic fluid.

Flight Operating Problems (21)

CLIMATIZATION

Cold Weather Operation of Aircraft; Survey of Operating Conditions, Shortcomings and Requirements in Sub-Zero Temperatures. G. W. Wilson and E. P. Bridgland. *Flight*, Vol. 54, No. 2079, October 28, 1948, pp. 523–525. (Extended summary of a paper.)

ICE PREVENTION & REMOVAL

Limitations and Mathematical Basis for Predicting Aircraft Icing Characteristics From Scale-Model Studies. Myron Tribus, G. B. W. Young, and L. M. K. Boelter. *American Society of Mechanical Engineers, Transactions*, Vol. 70, No. 8, November, 1948, pp. 977–982, figs. 6 references.

The equations that govern the motion of a water droplet impinging on an aerodynamic shape are used to obtain two moduli: one, the Reynolds modulus of the droplet; the other, a scale modulus that may be used to predict the icing characteristics of a structure from experimental data. The difference between flight speeds and the actual wind velocity atop Mount Washington requires that scale models be three to four times larger than the prototype so that dimensional similarity will be retained. In wind-tunnel studies, in order to minimize deviations in the trajectories of the droplets caused by the relative motion of the drop and the air, the spray device should be far ahead of the throat, and the model should be well back in the throat of the tunnel.

Analysis of Heat Transfer Over a Small Cylinder in Icing Conditions on Mount Washington. Myron Tribus, G. B. W. Young, and L. M. K. Boelter. *American Society of Mechanical Engineers, Transactions*, Vol. 70, No. 8, November, 1948, pp. 971–976, fig. 11 references.

A theoretical analysis of the heat required to maintain a heated rod dry and to maintain it with a small trace of ice. Data from experiments in which the rod was kept dry agreed within 30 per cent with the calculated heat requirements in all but approximately 10 per cent of the cases. Most observations agreed with theory within 15 per cent. A design is proposed for a meter to measure the liquid water content of a cloud through which an airplane is flying. The principle of this instrument is based on the determination of heat loss caused by evaporation. This loss is obtained by subtracting the computed heat loss due to convection from the measured total heat required to keep a rod moisture free.

PILOTING TECHNIQUE

A Note on Jet Aerobatics. A. Falorde. *Aeronautics*, Vol. 19, No. 6, November, 1948, pp. 75, 76, figs. Descriptions and sketches of the maneuvers performed by jet-powered aircraft at the British Aircraft Constructors' Display at Farnborough.

WEATHER HAZARDS

Windscreen Rain Repellent Developed. D. F. Stedman, *Canadian Aviation*, Vol. 21, No. 11, November, 1948, pp. 81, 82, diagrs.

FC.10 Rain Repellent, a wax protective coating for either glass or plastic windshields manufactured by Fiberglas Canada Ltd. under license from the National Research Council of Canada, gives excellent vision without optical distortion in extremely heavy rain at air speeds as high as 450 m.p.h. It is unaffected by deicing with either heat or alcohol.

An Analysis of the Airspeeds and Normal Accelerations of Boeing B-247 and B-247D Airplanes in Commercial Transport Operation. Walter G. Walker and Ivan K. Hadlock. *U.S., N.A.C.A., Technical Note No. 1783*, December, 1948. 12 pp., figs. 9 references.

Acceleration and air-speed data taken on Boeing B-247 transport airplanes are analyzed to determine the flight loads and oper-

ating speeds. Comparison of the results for the B-247 with the results for other airplanes shows larger than average flight loads, high operating speed ratio, but average route roughness of the operations. These results, together with analyses made in the past, indicate that operating speed in regions of turbulent air is a significant factor in operational life of the airplane.

Flight Safety & Rescue (15)

Smashing Eggs to Save Heads. *Popular Science Monthly*, Vol. 153, No. 6, December, 1948, pp. 116–119, illus., diagrs.

Description of research conducted at the Cornell Aeronautical Laboratory to investigate the cause of injury and death in airplane crashes. Eggs and models simulating the human head were used to find, under various conditions of restraint, the velocity that would produce injury upon impact with various materials. Data will be used to design aircraft interiors for maximum crash safety.

An Approach to Accident Prevention. W. E. Boud. *Indian Skyways*, Vol. 2, No. 9, September, 1948, p. 11.

In order to extend the sources of information sufficiently to provide significant statistical results, the Australian Civil Aviation Department has established a policy of investigating potential accidents as well as postaccident data. Potential accidents are occurrences incidental to the operation of aircraft in which the safety of the aircraft or its occupants is jeopardized.

They Leap to Rescue. James H. McLean. *Canadian Aviation*, Vol. 21, No. 11, November, 1948, pp. 26, 27, 88, illus. The Para-Rescue Team of the R.C.A.F. Search and Rescue Organization.

Flight Testing (13)

Air Force Precision Clocking Method for Jet Aircraft Speed Tests. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 22, November 15, 1948, pp. 11, 12.

Description of the benches, camera placements, course markers, and the photographic and electronic timing systems of the 3-km. speed test course at Rodgers Dry Lake, Muroc, Calif. The accuracy of the time, course, and speed expression that is obtained is greater than that required by the Fedération Aeronautique Internationale for official speed records.

Fuels & Lubricants (12)

The Self-Ignition of Mixtures of Hydrocarbons and Air Subjected to Very Sudden Adiabatic Compression (Die Selbstzündungsreaktion von Kohlenwasserstoffen bei kurzen Induktionszeiten). W. Jost. *U.S., Field Information Agency, Technical, Final Report No. 873*, September 20, 1946. 17 pp., tables. 2 references. (In German and English.) British Information Services, New York. $0.70.

An analysis of time-pressure curves obtained by Rogener and Braesch for mixtures of heptane and air subjected to rapid adiabatic compression. The combustion of hydrocarbons appeared to take place in two stages. The first is clearly a chain reaction, and the second appears to be probably a reaction of the same type. The overlapping of these two processes may give rise to a transient asymmetrical variation in the combustion velocity and may be the cause of detonation.

Better Lead Scavenging Needed for Aviation Gasoline. E. A. Droegemueller. *American Society for Testing Materials, Bulletin*, No. 154, October, 1948, pp. 53–56, illus., figs. 2 references.

The results of endurance tests, programmed to simulate typical flight schedules of a DC-6 airplane, in which the gasoline contained 1.5 times the amount of ethylene dibromide presently used as scavenger in aviation gasoline, showed that lead deposits were negligible. The excess scavenging material, however, formed residues that were highly corrosive to the metals used in the engine.

Gliders & Gliding (35)

Suction-Wing Glider; Interesting Australian Experiment with Griffith-Type Aerofoil. *Flight*, Vol. 54, No. 2086, December 16, 1948, p. 716, illus.

United States Soaring Records. Fritz Compton. *Soaring*, Vol. 12, No. 11-12, November-December, 1948, pp. 6, 7, illus.

Guided Missiles (1)

Limitations of the Long-Range Missile. Willy Ley. *Ordnance*, Vol. 33, No. 171, November-December, 1948, pp. 189–191, illus.

The vulnerability to interception of long-range missiles that are borne and controlled by aerodynamic forces, such as the German V-1 missile, when they are employed in ground-to-ground operations, make them less efficient than larger and more complex long-range rockets, such as the German V-2, which do not utilize aerodynamic forces. Because of its mobility and noninterceptibility and because it is cheaper than bombardment aircraft, the long-range rocket will probably prove to be the best long-range offensive weapon. It will not, however, supplant either artillery or bombardment aircraft, because all control must be effected during the initial portion of its trajectory. During the descent portion of the trajectory aerodynamic heating may cause incineration of the missile. The greater fuel supply needed for longer ranges requires an increase in the size and weight of the missile; this is an inherent limitation on its practicability.

Guided Missiles. VIII (Conclusion). A. R. Weyl. *The Aeroplane*, Vol. 75, No. 1953, November 12, 1948, pp. 616, 619–621, illus., tables.

A summary of the current status of long-range missile research in the U.S.S.R., Great Britain, and the U.S. The design and performance characteristics of 49 German, American, and British guided missiles are tabulated. The missiles are divided into three groups: the wingless missiles, winged missiles that are directed by radio, and winged missiles that are not radio-directed. The table gives the name, type, date, manufacturer, the type of power plant, method of stabilization, method of control weight, dimensions, method of launching, range, speed, and ceiling.

Instruments (9)

Application of Servo Systems to Aircraft. John R. Moore. *Aeronautical Engineering Review*, Vol. 8, No. 1, January, 1949, pp. 32–43, 71, diagrs., figs. 20 references.

The autopilot is used as an example of a typical servo system. The functions of its individual components are compared with the sensing, judging, and commanding activities of a human pilot to explain the basic concepts used in the design of servos. A synthesis of an autopilot illustrates the use of the principal analytical tools available to the engineer, such as the classical theory of linear differential equations with constant coefficients, operational mathematics, functions of a complex variable, Nyquist diagrams and Bode diagrams, the Nyquist stability criterion, and Bode's minimum phase network attenuation phase theorems. Both the transient and the steady-state types of analysis are developed and show the limitations of linearization and the special problems imposed by load variations and by noise. Further development of the art of servo design will be implemented by the development and application of dynamical analogues, digital computers, and other engineering aids, such as harmonic analyzers and synthesizers, Nyquist-diagram plotters, correlation-function computers, and Duhamel and Merrpry Function Integral machines. The competence of the servomechanism will be extended to encompass multiple inputs and outputs. The noise problem may be solved by signal selection on the basis of absolute magnitude of the signal and the noise. The combination of the open-cycle and the closed-cycle system will make it possible to design the feedback loop primarily from the standpoint of stability and noise elimination without jeopardizing steady-state or synchronizing operations.

Aviation's Incredible Dingus. Hiram Wilson Sheridan. *The Saturday Evening Post*, Vol. 221, No. 25, December 18, 1948, pp. 26, 27, 86, 88, 90, illus.

Account of a flight from La Guardia Field to McArthur Field, Long Island, during which the course and approach was controlled by the Sperry Zero Reader, and a comparison of the performance of this control system in approaches with ILS and GCA letdowns. The Zero Reader is a master aircraft-control device that will guide an airplane into a smooth turn and bank and place it on a preselected course at the desired altitude. After setting azimuth and altitude on the instrument, the pilot has only to keep the airplane pictured on the display of the instrument at the inter-

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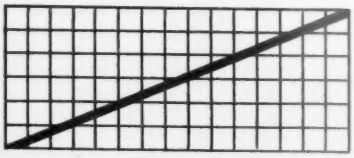

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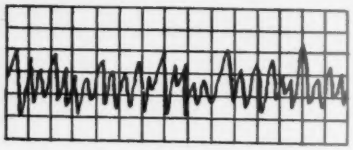
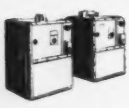


Designers often work under a handicap, because available test data covers only such properties as elastic limit, yield point, and ultimate strength. It leaves unanswered the biggest question of all—how *many* individual stressings can the material endure?

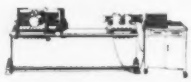
Today this *endurance* can be as accurately determined as the other physical properties, under conditions that simulate actual service conditions so closely that the results provide an accurate forecast of performance in the field. Here are some of the items in the Baldwin line of fatigue testing equipment.

Baldwin-Sonntag SF-2 Fatigue Testing Machine. Small, light motor-driven unit for bench mounting for testing sheet materials in flexure. Adjustable alternating force up to 20 lbs.

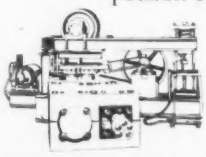
Baldwin-Sonntag Universal Fatigue Testing Machines. For testing materials or parts in tension, compression, torsion, bending or combined stresses. Maximum force—SF-01-U, 200 lbs.; SF-1-U, 2000 lbs.



Baldwin-Sonntag SF-20-U Universal Fatigue Testing Machine. The most versatile machine currently available. Maximum force 20,000 lbs.—48-inch distance between platens—large permissible amplitude.



R. R. Moore High Speed Rotating Beam Fatigue Testing Machine. A new improved model, with greatly expanded testing capacity. Variable speed, automatic cut-off, cycle counter. Specimen can be loaded to 200 inch-pounds. Rated at 10,000 r.p.m.



Other Baldwin Fatigue Testing Equipment. The Baldwin line includes a number of special fatigue testing machines, such as the Lazan Oscillator, the Rolling Load Fatigue Machine, the BF Fatigue Machine, and others. If you have any special problems, ask about this special equipment.

Ask For Technical Literature. Informative, illustrated bulletins on various items of Baldwin Testing Equipment have been prepared, and are available on request Just designate what machine you are interested in, or the type of testing you want to do.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Boston, New York, Philadelphia, Houston, St. Louis, Chicago, Cleveland, Pittsburgh, San Francisco, Seattle, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

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section of the vertical and horizontal cross-airs. The instrument gives the control commands necessary to bring the craft to the approach area of its terminal airport. When an ILS glide-beam signal is then fed into the system, which has been reset for the approach course, the Zero Reader brings the airplane down, centered on the runway, with no apparent hunting or overshooting.

Oscillating-Piston Meters for Fuel Consumption in Aircraft. C. S. Hazard. *American Society of Mechanical Engineers, Transactions*, Vol. 70, No. 8, November, 1948, pp. 923–927, diagrs., figs. 9 references.

The A.A.F. Class 30 and the A.A.F. H-1 fuel flowmeters are designed for maximum operating pressures of 35 and 600 lbs. per sq.in., respectively. These oscillating-piston, positive-displacement meters register the volumetric throughput of kerosene or gasoline aircraft fuels within a tolerance of ±0.2 per cent at operating temperatures between 130° and −60°F.

Laboratories, Aeronautical (50)

Canadair Test Lab. *Aircraft and Airport*, Vol. 10, No. 10, October, 1948, pp. 24–27, illus., cutaway drawing.

Visits in American and French Zones: Aircraft and Aircraft Engines. D. M. Holman, J. J. Green, R. D. Hiscocks, and T. Orr. *Gt. Brit., British Intelligence Objectives Sub-Committee Final Report No. 170, Item No. 25, 26.* 11 pp. British Information Services, New York. $0.55.

Flanged Joint Design for Welded Tubular Steel Structures. Grant A. DeShazer. *Product Engineering*, Vol. 14, No. 11, November, 1948, pp. 117, 118, illus., diagrs. This design is used in the towing carriage at the David W. Taylor Model Basin in order to maintain structural alignment and strength in a structure that is designed to be assembled and disassembled in sections.

Navy Demonstrates World's Largest Universal Testing Machine. Instruments, Vol. 21, No. 10, October, 1948, pp. 876, 878, illus

The Baldwin universal testing machine at the Aeronautical Structures Laboratory at the Philadelphia Naval Base has a capacity of 5,000,000 lbs. The applied loads, in tension or compression, are measured by a hydraulic system employing an Emery cell and a Tate-Emery indicator.

Laws & Regulations (44)

Streamlining the Rules for Safe and Sane Regulation. D. W. Rentzel. *U.S., Air Services*, Vol. 33, No. 12, December, 1948, pp. 22, 24. (An address.)

The Legal Aspects of Indian Aviation. M. H. Kantawala. *Indian Skyways*, Vol. 2, No. 9, September, 1948, pp. 35, 37, 38.

Machine Elements (14)

Intermittent Mechanisms. III. Guy J. Talbourdet. *Machine Design*, Vol. 20, No. 11, November, 1948, pp. 159–163, diagrs., figs.

Equations of the input and output motions of gear systems that incorporate a dwell period in the output motion of an intermittent mechanism. Two designs modify the motion of the cage in the basic planetary system: one by a rack or segment and a cam control; the other by a gear segment and oscillating follower. A third system employs a screw and gear with cam control.

Accelerations by Vector Methods in Disk Cam Mechanisms. Jesse Huckert. *Product Engineering*, Vol. 19, No. 12, December, 1948, pp. 128–132, diagrs.

Superprecision Ball Bearings. I—Selection for Design and Type. II—Selection for Grade of Accuracy and Speed. Thomas E. Rounds. *Machine Design*, Vol. 20, Nos. 11, 12, November, December, 1948, pp. 103–108; 122–124; figs., tables.

Maintenance (25)

An Airline Maintenance Base in the U.S.A.; An Account of the Elaborate Equipment at the United Air Lines Maintenance Base at San Francisco. H. W. Perry. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, pp. 370–372, illus.

R.Ae.C. (Royal Aero Club) Maintenance Schedules for Light Aircraft. *Flight*, Vol. 54, No. 2084, December 2, 1948, p. 650.

The Technique of Wire Locking; The Tightening Up of Regulations Has Caused Designers and Manufacturers to Pay More Attention to the Technique Employed in the Wire Locking of Fuel and Oil Pipes. J. W. Tomlinson. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, p. 366, diagrs.

Materials (8)

Plastic Flow, Creep, and Stress Relaxation. IV—Anomalous Flow as an Order-Disorder Transition. Charles Mack. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 1082–1091, figs. 20 references.

METALS & ALLOYS

Quantitative Treatment of the Creep of Metals by Dislocation and Rate-Process Theories. A. S. Nowick and E. S. Machlin. *U.S., N.A.C.A., Report No. 845*, 1946, 10 pp., figs. 22 references.

An equation for the steady-state rate of creep has been derived by applying the theory of dislocations to the creep of pure metals. The form of this equation is in agreement with empirical equations describing creep rates. The theory was also used to predict the dependence of steady-state rate of creep on physical constants of the material, and good agreement was obtained with data in the literature for pure annealed metals. The rate of creep was found to decrease with increasing modulus of rigidity. This relation suggests that one of the requirements for a heat-resisting alloy is that its matrix be a metal that has a high modulus of rigidity and therefore a high modulus of elasticity.

Tungsten and Molybdenum Metallurgy of Japan. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1431*, November 30, 1946. 25 pp., figs. British Information Services, New York. $0.90. Sources of supply, import statistics, and methods used to process crude tungsten and molybdenum concentrates in the production of metal powder, ingots, and bars.

The Contribution of Modern Physics to Metallurgy. Frederick Seitz. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 973–987, diagrs., figs. 9 references.

Metal Finishing Process Information Sheets. III—Aluminum. George Black. *Product Engineering*, Vol. 19, No. 12, December, 1948, p. 159. The phosphoric acid anodic, zincate, Alumon, and Sat-N-Dip processes.

Mechanical Tubing as an Engineering Material. H. R. Clauser. *Materials & Methods*, Vol. 28, No. 6, December, 1948, pp. 91–104, illus. Characteristics of mechanical tubing, forming and fabricating methods, steel tubing, copper-alloy tubing, nickel and nickel-alloy tubing, light metal tubing, and specialty tubing.

NONMETALLIC MATERIALS

Molybdenum Coated for High-Heat Use. *Aviation Week*, Vol. 49, No. 20, November 15, 1948, pp. 32, 33.

N.A.C.A. high-temperature ceramic-coating research. The oxidation of molybdenum at working temperatures as high as 3,500°F. was substantially retarded by a coating consisting of a base coat of a low-expansion frit with 20 per cent zirconia, a cover coat containing 95 per cent zirconia, and a seal coat of the same composition as the base coat. Ceramic-coated molybdenum pitot tubes for the nozzle end of ram-jets showed a life of more than 45 min. at gas temperatures of approximately 3,000°F.

Prof. Dr. Ing. Emil Sorensen, Maschinenfabrik Augsburg-Nurnberg, A.G. S. T. Robinson and R. S. Sproule. *Combined Intelligence Objectives Sub-Committee, Item No. 5, File No. 27-20*, June, 1945. 8 pp. British Information Services, New York. $0.35. A summary of the results obtained by the Maschinenfabrik Augsburg-Nurnberg A.G. in the development of ceramic turbine blades. Appendix lists 22 German firms and laboratories engaged in gas-turbine research and development.

An Improved Low-Temperature Brittleness Test. E. F. Smith and G. J. Dienes. *American Society for Testing Materials, Bulletin*, No. 154, October, 1948, pp. 46–49, illus., figs. 1 reference.

Description of a machine that will test the brittleness at low temperatures of five specimens simultaneously. The increased amount of data provided by the device facilitates the statistical study of the distribution of per cent failures vs. temperature. Sample data given for various elastomers show that many do not

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possess a sharply defined brittle point but are characterized by a distribution of failures over a temperature interval.

Large Deformations of an Elastic Solid. E. G. Chilton. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 362–368, illus., figs. 11 references.

Meteorology (30)

Growth of Charged Particles in Clouds. Wulf Kunkel. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 1053–1055, fig.

Calculations to estimate the cloud density and average charge of a cloud of dust particles or droplets of liquid required for an appreciable particle growth to take place. Integration of the equation of relative motion of two charged particles yields their effective cross section for aggregation. From this, if the particle size and the charge distribution of the cloud are known, the rate of growth can be determined. If highly simplified distribution is assumed, the aggregation is negligible when the density of the cloud is less than a million particles per sq.cm. or when the average charge of one sign is well below 1,000 electrons per particle.

A Note on the Semi-Diurnal Pressure Oscillation in the Free Atmosphere. T. E. W. Schumann. *American Meteorological Society, Bulletin*, Vol. 29, No. 9, November, 1948, pp. 466, 467. 2 references.

Some Experience in Forecasting Clouds over Kansas from the Slopes of Isentropic Surfaces. J. D. Hubbard. *American Meteorological Society, Bulletin*, Vol. 29, No. 9, November, 1948, pp. 462–466, figs.

Military Aviation (24)

All-Jet Bomber Air Force? U.S. Air Policy and Bomber Development. *Flight*, Vol. 54, No. 2083, December 25, 1948, pp. 629–633, illus.

. The Strength of the Royal Air Force. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, p. 725.

Exercise Sunrise; Simulated Air/Sea Warfare as Seen From H.Q., and Costal and Bomber Bases. *Flight*, Vol. 54, No. 2086, December 16, 1948, pp. 709–713, illus.

With the Air-Lift Again. John Fricker. *The Aeroplane*, Vol. 75, No. 1954, November 19, 1948, pp. 643–645, illus., map. With table of aircraft, operating bases, and operating units.

"Plainfare" Service; Activity at (R.A.F.) Transport Command Central Servicing Unit in Keeping the Berlin Air Lift at Full Serviceability. *Flight*, Vol. 54, No. 2084, December 2, 1948, pp. 649, 650, illus.

Manning the R.A.F.; Better Pay, Accommodation and, Above All, Discipline, the Key to the Solution. Sir Philip Joubert. *Flight*, Vol. 54, No. 2085, December 9, 1948, pp. 679–681.

High Speed Aircraft on Carriers. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, pp. 727, 728, illus.

Why the Navy Wants Supercarriers. Phil Gustafson. *Popular Science Monthly*, Vol. 154, No. 1, January, 1949, pp. 114–120, illus. Some design features of the U.S. Navy CVA-58 aircraft carrier.

Review of Ground Anti-Aircraft Defense. Preston R. Bassett. *Sperryscope*, Vol. 11, No. 7, Autumn, 1948, pp. 16–20, illus. A brief review of the developments that have taken place in anti-aircraft fire control since World War I.

Operations

COMMERCIAL (41)

Some Economic Factors in Civil Aviation, with Emphasis on Civil Aircraft and Their Prospective Trends of Development. Peter G. Masefield. *Royal Aeronautical Society, Journal*, Vol. 52, No. 454, October, 1948, pp. 575–718, diagrs., figs., fold. charts. 51 references.

A detailed analysis of the costs and performance of current and prospective commercial transport aircraft. Although the air-transport industry is fundamentally a commercial business, the political, diplomatic, cultural, security, and trade assets that accrue to the nation from it justify its subsidy at the present time. An analysis of the performance and economics of seven aircraft typical of those in current commercial use shows that the industry can be developed on sound economic lines. The deficit under which all air lines operate can be attributed to some extent to the abnormally high overhead costs that have been caused by the initial expansion of the air lines. A more serious cause is the inefficiencies that arise from the failure to match each type of aircraft to the route for which it is most suited. Lower overhead and more efficient operation will make it possible to reduce fares and thus broaden the base of the traffic potential. The trend in aircraft design is toward higher speeds at lower costs by reduction of aerodynamic drag and improvement in fuel consumption. Each type of power plant has its sphere of maximum efficiency. The reciprocating engine has the advantage of flexibility of performance, and it is suitable for all but extremely long ranges. It is most efficient on stage lengths not exceeding 2,000 miles. For greater distances, the compound piston engine promises to be even more flexible. The turboprop is most suitable for medium-range operations. Eventually, however, it will be developed to a point where, if traffic control is improved, it will be superior to the piston engine for all but extremely short or extremely long ranges. The jet engine, because its greater speed would make higher utilization possible, promises maximum economic advantage for operations ranging between 300 and 700 miles. At present, however, no small jet transport can be operated commercially because of the restrictions imposed by current air-traffic control procedures. The commercial helicopter will probably be most useful in stages of from 50 to 100 miles. Unless a route crosses geographical barriers, fixed-wing aircraft cannot compete with efficient surface transport on runs of less than 200 miles. Development in the length and strength of airport runways has reached an economic ceiling that will require new aircraft designed to fit existing airports. Efficient operations, with advanced types of aircraft that are matched to the routes, promise economic costs no higher per mile than those of surface transport.

How Airlines Can Lease Convairs. *Aviation Week*, Vol. 49, No. 20, November 15, 1948, pp. 46, 47. An outline of the proposed contractual arrangements between the Convair Equipment Corporation and the air lines, and the contemplated financial structure of the corporation.

Frontiers Being Pushed North by Government Air Services. *Canadian Aviation*, Vol. 21, No. 11, November, 1948, pp. 40, 48, illus. Activities of the Saskatchewan Government Airways.

Booking Air Passengers; B.E.A. in Dorland Hall; Flexible System to Meet Peak Demands. *Modern Transport*, Vol. 60, No. 1546, November 13, 1948, p. 7.

British Air Lines' Second Financial Year. *The Aeroplane*, Vol. 75, No. 1956, December 3, 1948, pp. 709, 710, illus.

Two Important Years; A Review of the Official Report on (British) Civil Aviation During 1946 and 1947. *Flight*, Vol. 54, No. 2085, December 9, 1948, pp. 687, 688.

Soviet Air Transport; Extensive Network of Services. *Modern Transport*, Vol. 60, No. 1548, November 27, 1948, pp. 9, 10, illus., map. Includes an extensive list of the stops along the international and domestic routes of Aeroflot as of the summer of 1948.

Chinese Air Transport; Development Under Difficulties. *Modern Transport*, Vol. 60, No. 1548, November 27, 1948, p. 11.

China's Gallant Airline. *Indian Skyways*, Vol. 2, No. 9, September, 1948, pp. 26–29, illus. A brief review of the development of civil aviation in China.

Indian Airlines—Their Future Policy. R. Vaughan Fowler. *Indian Skyways*, Vol. 2, No. 9, September, 1948, pp. 21–25.

Pakistan's Aviation Problem. H. M. Nolan. *Indian Skyways*, Vol. 2, No. 9, September, 1948, pp. 13–17, 19, illus.

Ordnance & Armament (22)

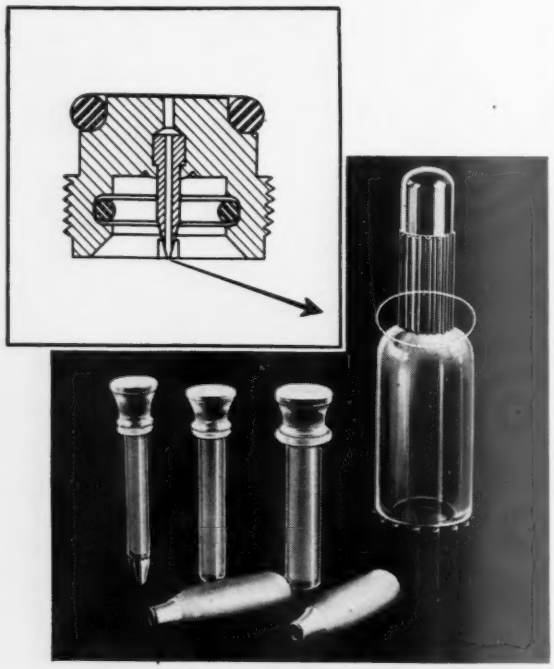
Ball Release Mechanism Triggers Shock-Testing Air Gun. John H. Armstrong. *Machine Design*, Vol. 20, No. 11, November, 1948, pp. 95–99, illus., cutaway drawings.

A testing device for weapons and their components to determine their response or resistance to acceleration. A two-stage ball release incorporated in the firing mechanism of an air gun permits independent control of the time from initial movement until complete freedom of the piston.

Photography (26)

An Electronically Operated Kerr Cell Shutter. K. D. Froome. *Journal of Scientific Instruments*, Vol. 25, No. 11, November, 1948, pp. 371–373, diagrs. 2 references.

What has Cryotherapy to do with LINEAR "O" RINGS?



Simply this, Cryotherapy is the medical treatment of skin disorders by the use of carbon dioxide snow. Now this treatment is made practical—simple—effective—and economical by the invention of the Kiddie Dry Ice Machine. This dry ice machine is made possible by the use of LINEAR "O" rings.* The "O" rings act as a seal between the neck of the gas cylinder and the cylinder piercing assembly. This assembly is in turn sealed to the discharge orifice with another "O" ring used as a static seal on three surfaces. LINEAR "O" rings are performing successfully on the Kiddie Dry Ice Machine at pressures of 900 PSI and temperatures that momentarily drop to −110° F.

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The circuit produces a sequence of 10–12 kv. square-wave pulses suitable for operating a small Kerr-cell shutter. The width of the pulses (i.e., the shutter exposure) and the interval between them can be varied independently of each other. The number of exposures can likewise be altered, and provision is also made for single exposures.

Power Plants

JET & TURBINE (5)

The Fundamental Principles of Lorin Ram-Jet Powered Airplanes. E. Sänger. (*France, Ministère de l'Air, Service de Documentation et d'Information Technique, Bulletin Mensuel de Documentation*, No. 29, September, 1947.) *University of Illinois, Institute of Aeronautics, Translation*, 1948. 59 pp., diagrs.

A detailed analysis of the theory and the performance characteristics of subsonic and supersonic Lorin power plants. Designs are developed for external, internal, and supersonic diffusers; fuel systems using liquid hydrocarbons, solid and pulverized coal, and atomic energy; and the systems that are required to control the rate of heat exchange, diffuser characteristics, and thrust-nozzle area. The results of 130 test flights are summarized in which oil-burning Lorin power plants were installed on flying test beds. The performance characteristics of proposed subsonic and supersonic Lorin-powered aircraft designs are developed, and formulas are obtained which, under conditions of constant velocity and altitude in level flight, show the fuel consumption per meter of trajectory and per kilogram of flight weight, the variation of the range with the ratio of the wing area to the power-plant cross section and the appropriate lift coefficients, and operating temperatures. At high subsonic flight velocities at altitudes up to 65,600 ft., this type of power plant gives a rate of climb of about 39,300 ft. per min. and in level flight has a flight duration comparable to that of turbojet military pursuit aircraft. At high supersonic velocities the Lorin power plant attains an efficiency higher than obtained by the reciprocating engine and propeller power plant in its own speed range. The power output at wide open throttle is plotted as a function of flight speed for the turbojet, pulse-jet, rocket, and reciprocating engines, and the Lorin power plant. Comparative numerical values of the performance characteristics are tabulated for jet engines employing liquid fuels.

Calculated Performance of a Compression-Ignition Engine-Compressor-Turbine Combination Based on Experimental Data. Alexander Mendelson. *U.S., N.A.C.A., Technical Note No. 1774*, December, 1948. 28 pp., figs. 7 references.

Calculations based on data obtained on a single-cylinder compression-ignition engine with a compression ratio of 13.1 and an engine speed of 2,200 r.p.m. were made to determine the performance at sea-level conditions of a compression-ignition engine geared together with a compressor and a turbine. The effects of fuel-air ratio, compression ratio, exhaust back pressure, and engine speed on the performance of the combination were determined. Comparison with a compression-ignition engine using a turbosupercharger showed that little could be gained by gearing the turbine to the engine, provided the turbosupercharger could be stably operated with a closed waste gate.

Interrogation of Dipl. Ing. Helmut Schelp. S. T. Robinson. *Combined Intelligence Objectives Sub-Committee, Item Nos. 5, 26, File No. 32-46*, August, 1945. 13 pp. British Information Services, New York. $0.55.

A preliminary interrogation of Helmut Schelp, of the Reichsluftfahrtministerium, who was responsible for German policies pertaining to the development of gas-turbine power plants for aircraft. Includes range and power requirements established in 1939; a list of all the turboprop and turbojet engines developed under this program; an explanation of the RLM designation numbering system; type-test requirements; a list of test facilities; and the names of the principal men working in each of the firms engaged in gas-turbine work.

Gas Turbines at Farnborough. Paul H. Wilkinson. *Aero Digest*, Vol. 57, No. 5, November, 1948, pp. 22–25, 109, 110, illus.

A survey of the British aircraft gas-turbine industry, covering the activities of the principal manufacturers and their current designs. Turboprop engines have been developed principally for commercial transports. Turbojets, on the other hand, are intended for use in military aircraft. A comprehensive and developed engine-accessory industry shows that the British aircraft

gas-turbine program is well balanced and has been carefully planned.

Internal Combustion Turbines. *Flight*, Vol. 54, No. 2081, November 11, 1948, pp. 580, 581, figs.

Summaries of lectures given during November, 1948, by the Staff of the National Gas Turbine Establishment before The Institution of Mechanical Engineers: Performance of Axial Flow Turbines, D. G. Ainley; The Prospects of Land and Marine Gas Turbines, Hayne Constant; The Fuel Problem in Gas Turbines, Peter Lloyd; Heat Flow in the Gas Turbine, A. G. Smith; Three-Dimensional-Flow Theories for Axial Compressors and Turbines, A. D. S. Carter; The Part-Load Performance of Various Gas-Turbine Engine Schemes, D. H. Mallinson and W. G. E. Lewis.

Reveal Increased Turboprop Efficiencies. Ivan H. Driggs. *Aviation Week*, Vol. 49, No. 20, November 15, 1948, pp. 29–32.

The efficiency of a turbojet engine is calculated as the ratio of the power available for propulsion to the total power available in order to permit a comparison of the efficiencies of turboprop and turbojet engines. The maximum efficiency of a turbojet with no friction loss in the tailpipe or nozzle is shown to be 50 per cent in theory and approximately 47.5 per cent in practice. In the turboprop engine the total thrust power depends on the ratio between the power removed to drive the propeller and the total power available. When this ratio is selected to give the maximum propulsive efficiency, the turboprop may be considerably more efficient than the turbojet up to speeds much higher than 500 m.p.h., which is normally assumed to limit its maximum efficiency.

Centrifugal Castings for Jet Engines. Nathaniel F. Silsbee. *Aero Digest*, Vol. 57, No. 5, November, 1948, pp. 47, 104, 105, illus. The Turbo-Wasp J-6B is being produced by Pratt & Whitney aircraft under license from Rolls-Royce, Ltd. Centrifugal castings for the rings, valves, and sleeves of the engine are supplied from American foundries.

Packard Concentrates on Turbine Engines. *Canadian Aviation*, Vol. 21, No. 11, November, 1948, pp. 28, 29, illus. Gas-turbine research and test facilities at the Toledo plant of the Packard Motor Car Company, which include two supersonic wind tunnels and a vortex wind tunnel.

Development of the (Armstrong Siddeley) Mamba Engine. W. H. Lindsey. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, p. 729. (Extended summary of a paper.)

Development of the Mamba; Reduction Gear, Compressor, Combustion Chambers and Controls. W. H. Lindsey. *Flight*, Vol. 54, No. 2085, December 9, 1948, pp. 696–699, figs. (Extended summary of a paper.)

Visit to M.A.N. Laboratory, Augsburg. R. J. Keig and J. A. Cowderoy. *Combined Intelligence Objectives Sub-Committee, Item No. 18, File No. 33–11*, May, 1945. 13 pp. British Information Services, New York. $0.70.

Readers' Forum: On Sweat Cooling. E. A. Richardson. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 62, 63.

Ways and Nenes; Illustrative of the Manner in Which British, French, and American Designers Have Utilized a Rolls-Royce Turbojet. *Flight*, Vol. 54, No. 2086, December 16, 1948, pp. 719–721, illus.

Dart Details; Rolls-Royce's Small Turboprop Described. *Flight*, Vol. 54, No. 2084, December 2, 1948, p. 651, illus.

RECIPROCATING (6)

Optimum Ratio Between Crank Arm and Connecting Rod for Smooth Operation of Reciprocating Engines. W. S. Kimball. *Franklin Institute, Journal*, Vol. 246, No. 5, November, 1948, pp. 409–418, figs.

A study of the magnitude of the crosshead acceleration maxima and their angular position in the engine cycle which shows how these maxima vary for different values of the ratio of the crank arm to the length of the connecting rod. For all ratios slightly larger than the usual 1/4 there are three maxima per cycle instead of the two at the ends of the stroke, as with simple harmonic motions. Two of these maxima are positive crosshead acceleration maxima. They occur where the crank arm is at two symmetric positions before and past the position away from crank opposite the cylinder at angular position $\theta = \pi$, the stroke end, where positive acceleration is maximum for simple harmonic motions. These two positive crosshead acceleration maxima have a smallest (equal) value, or minimum, under variations when the crank-arm to connecting-arm ratio is 0.357. They occur at cycle angle $\pm 132°$, which is $\pm 48°$ away from the stroke end position at which the positive maximum for simple harmonic motion occurs.

H. and C. Mod. Convair. *Flight*, Vol. 54, No. 2081, November 11, 1948, p. 579, illus. The Consolidated exhaust-augmentor system installed on the Convair 240.

Observations of the Lubricating Oil Film Between Piston Ring and Cylinder of a Running Engine. J. C. Wisdom and R. L. Brooks. *Australia, Council for Aeronautics, Report No. ACA-37*, July, 1947. 28 pp., illus., diagrs., figs. 5 references.

Equipment and experimental technique used to investigate the lubrication between piston ring and cylinder by measuring their mutual electrical contact resistance. Data obtained from a single-cylinder aircraft engine running under its own power at speeds up to 2,000 r.p.m. and under various operating conditions show that full fluid lubrication never exists for the whole of the engine cycle. The breakdown of the lubricating-oil film at the upper position of piston travel that was observed correlates with known data on cylinder wear. Breakdown is facilitated by low engine speed, high gas pressure in the cylinder, low oil circulation, and high cylinder temperature. Ignition advance beyond the optimum point increases the breakdown, and, if detonating conditions obtain, wear near the top of the cylinder will be greatly increased.

Production (36)

Co-Ordinating Design and Manufacture in the Development of a Complex Machine. G. R. Heil. *Machine Design*, Vol. 20, No. 11, November, 1948, pp. 117–120, illus., figs.

A discussion of the plant organization and systems used by the Wright Aeronautical Corporation in order to ensure that during the design and development of an aircraft engine the experimental manufacturing, the production manufacturing, the purchasing and other affected departments are kept informed of the works in progress. The project is initially scheduled by the budget and planning division of the engineering department. A framework of controls is set up which includes an IBM record that lists all the parts ordered on each project. The IBM record is republished semimonthly and reflects modifications and changes in the original design which have been introduced after consultation between the design and production engineers. This overall scheduling and this detailed control fosters intimate cooperation between the design, production, experimental manufacturing, and materials-control personnel.

German Airframe Tooling—General. R. G. Bowen, S. S. Cross, Ray Elliott, Palmer Nicholls, and Henry Steinmeier. *U.S., Field Information Agency, Technical, Final Report No. 100.* 8 pp., figs. British Information Services, New York. $0.35.

A comparison of the tooling practices of Dornier-Werke with those of Messerschmitt show them to be identical. Included are a description and a sales leaflet, in German, of a profile milling machine designed by Messerschmitt. The operator cuts successive mold lines on the workpiece by tracking a metal draft that moves with the workpiece and is magnified and projected optically on a viewing screen.

Production Processes, Their Influence on Design. XXXVIII—Spot Welding. Roger W. Bolz. *Machine Design*, Vol. 20, No. 11, November, 1948, pp. 127–135, illus., diagrs., figs.

Determining Dimensional Relationships in Complex Parts. Charles H. Buccola. *Product Engineering*, Vol. 19, No. 12, December, 1948, pp. 133–136, diagrs., figs.

Primers in Production (Fairey Trainers). *The Aeroplane*, Vol. 75, No. 1955, November 26, 1948, pp. 670–672, illus.

Propellers (11)

Vibration of Stationary and Rotating Propellers. E. R. Love, J. P. O. Silberstein, and J. R. M. Radok. *Australia, Council for Aeronautics, Report No. ACA-36*, June, 1947. 54 pp., tables. 18 references.

A comparative survey of the principal theoretical studies on the vibration of stationary and rotating propellers, introduces a theory for small vibration of a propeller which only requires that the propeller blades be straight and slender and that their section and twist vary gradually along their length. Transformations show the relations of the integral equations obtained with this theory to those derived by other methods. Extension of the

theory to the idealized propeller vibrating about a rotating equilibrium position yields results that show the stationary propeller as a special case. The extension applies to a propeller not only when the hub is driven at a uniform speed but also when the drive shaft is in torsional vibration. The latter case is developed directly from dynamic principles without the use of the approximate formula of Southwell and Gough. The method used to obtain an approximate solution of the equations for a given propeller yields the mechanical impedance of the propeller at its hub at any frequency. As in most vibration studies of continuous systems, this method requires the selection of a finite number of representative coordinates that approximate the system and the solution of a determinantal equation, usually of the same order. In this method, the order is approximately halved, thereby reducing the computation required for a given range of frequencies. Independent and general notation is used to present a technique of solution of determinantal equations whose elements are polynominals, and a system of control and estimation of accuracy is included. The impedance-frequency relations are calculated numerically for a de Havilland propeller to illustrate the application of the theory and to show the amount of computation it entails.

Propellers in Yaw. Herbert S. Ribner. *U.S., N.A.C.A., Report No. 820*, 1945. 23 pp., figs. 17 references. U.S. Govt. Printing Office, Washington. $0.20.

Rotating Wing Aircraft (34)

Engineering Problems of the Helicopter. F. N. Piasecki. *Shell Aviation News*, No. 124, October, 1948, pp. 17–22, illus., diagrs., figs.

A summary of helicopter engineering problems and their solution in current design trends. Discussion includes: helicopter performance and disc loading; rotor-blade strength, freedom and method of attachment; power-engagement and overrunning clutches, reduction gearing, and flexible-joint shafting in power-transmission systems; power-plant cooling; power and rotor speed; control and stability; air-frame structural loads; and landing-gear, wheel, and shock-absorber design.

An Outline of Helicopter Design. III. John C. Vogtle. *American Helicopter*, Vol. 12, No. 12, November, 1948, pp. 12, 19–21, figs. 4 references. Engineering studies of the power-plant, landing-gear, and structural components.

Helicopter Problems; Discussion of Five Papers at R.Ae.S. and H.A. All-Day Meeting. *Flight*, Vol. 54, No. 2085, December 9, 1948, pp. 694, 695.

Symposium on Helicopters (November 20, 1948, Royal Aeronautical Society and Helicopter Association of Gt. Britain). I. *The Aeroplane*, Vol. 75, No. 1956, December 3, 1948, pp. 699, 700, 704–708, illus., figs.

Discussing the Helicopter; All-Day Joint Meeting of the Royal Aeronautical Society and the Helicopter Association of Great Britain. *Flight*, Vol. 54, No. 2083, December 25, 1948, pp. 636–640, illus., diagrs., figs. Summaries of papers by R. A. C. Brie, R. N. Liptrot, J. A. J. Bennett, Raoul Hafner, and J. Shapiro.

Discussing the Helicopter Lectures. II. *The Aeroplane*, Vol. 75, No. 1957, December 10, 1948, p. 741.

Flying Flitgun. Harold Olsen. *American Helicopter*, Vol. 12, No. 12, November, 1948, pp. 13, 21, 22, illus. Spraying of DDT by helicopters to control budworms in Oregon forests.

Power-Line Patrol; How Helicopters Save Time and Money i

America: An Unpremeditated Night-Flight Emergency Landing C. Colin Cooper. *Flight*, Vol. 54, No. 2086, December 16, 194 pp. 714, 715, illus.

Problems Confronting Helicopter Passenger Service. Roy W Lewis. *American Helicopter*, Vol. 12, No. 12, November, 194 pp. 9, 10, 17–19.

Economic Factors Relating to Helicopter Air Mail Operation Jack E. Rothman. *American Helicopter*, Vol. 12, No. 12, Novem ber, 1948, pp. 15, 16. (Summary of a paper.)

Discussing the Helicopter; The Cierva W.11 "Air Horse" De scribed and Evaluated: Advantages and Disadvantages of Thre Rotors. *Flight*, Vol. 54, No. 2084, December 2, 1948, pp. 665–668 illus., diagr., figs. (Extended summary of a paper by J. Shapiro.)

Hiller 360 Granted Commercial License. George Wale *American Helicopter*, Vol. 12, No. 12, November, 1948, pp. 8, 22 illus.

New 'Copter Almost Flies Itself (Kaman Twin-Rotor Helicop ter). Devon Francis. *Popular Science Monthly*, Vol. 154, No. 1, January, 1949, pp. 182–184, illus., diagrs.

Kellett XR-10. *Aero Digest*, Vol. 57, No. 5, November, 1948, p. 55, illus.

A Pulsejet Helicopter (Marquardt M-14 Whirlajet). *Aero Digest*, Vol. 57, No. 5, November, 1948, p. 54, illus.

Sciences, General (33)

MATHEMATICS

On the Integration of Hyperbolic Differential Equations. A. Robinson. *College of Aeronautics, Cranfield, England, Report No. 18*, July, 1948. 26 pp. 8 references.

A method for the analysis and integration of linear partial differential equations of two independent variables and of arbitrary order for initial conditions that are considerably less stringent than those required by the methods of Friedrichs and Lewy, Rellich, and Herglotz. The initial equation is replaced by a system of two linear partial differential equations of the first order and a single equation of the same type. The left-hand side of the expression represents the derivatives along one of the characteristic curves of the system. Integration is accomplished by a step-by-step method or by a method of successive approximation. Since the integration is carried out along the characteristic curves, there is no possibility of a failure with this method such as may occur when certain lattice methods are used. Even though the total number of integrations required for the solution of an equation of fairly high order is extremely large, this procedure may form a suitable basis for work on a modern calculating machine.

A Digital Computer for Scientific Applications. C. F. West and J. E. DeTurk. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 12, December, 1948, pp. 1452–1460, illus., diagrs. 7 references.

MECHANICS

Vibration of a Nonlinear System During Acceleration Through Resonance. R. B. Meuser and E. E. Weibel. **Discussion.** F. M. Lewis. *Journal of Applied Mechanics*, Vol. 15, No. 4, December 1948, pp. 388, 389. 1 reference.

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Stress Analysis & Structures (7)

Efficient Applications of Stringer Panel and Multicell Wing Construction. George Gerard. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 35–40, figs. 5 references.

Under the structural loading conditions of transonic Mach Number flight, the stringer panel type of wing construction and multicell construction were examined to determine the conditions under which each indicated efficient structural applications. From an analysis of structures of optimum design, stringer panel wings appear to have a wide range of efficient application. Only in the range of extremely high loadings and small thickness ratios does multicell construction indicate efficient applications. It is to be noted that the results obtained are strongly influenced by practical considerations involved in the manufacture of such wings.

Bending-Torsion Flutter Calculations Modified by Subsonic Compressibility Corrections. I. E. Garrick. *U.S., N.A.C.A., Report No. 836*, 1946. 6 pp., figs. 5 references. U.S. Govt. Printing Office, Washington. $0.10.

A number of calculations of bending-torsion wing flutter are made at two Mach Numbers, $M = 0$ (incompressible case) and $M = 0.7$, and the results are compared. The air forces employed for the case of $M = 0.7$ are based on Frazer's recalculation of Possio's results, which are derived on the assumption of small disturbances to the main flow. For ordinary wings of normal density and of low bending frequency in comparison with torsion frequency, the compressibility correction to the flutter speed appears to be of the order of a few per cent; whereas, the correction to the flutter speed for high-density wing sections, such as propeller sections, and to the wing-divergence speed in general may be based on a rule using the $(1 - M^2)^{1/4}$ factor and, for $M = 0.7$, represents a decrease of the order of 17 per cent.

The Flutter of a Uniform Wing with Tip Weights. Martin Goland and Y. L. Luke. **Discussion.** R. H. Scanlan. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 387, 388.

Readers' Forum: Induction Effects in Aeroelasticity. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 16, No. 1, January, 1949, pp. 63, 64.

Testing Highly Stressed Structures. W. B. Miller and E. H. Schwartz. *Product Engineering*, Vol. 14, No. 11, November, 1948, pp. 81–84, illus.

A description of tests and methods of evaluating structural-load data obtained by static, dynamic, and fatigue tests of major aircraft components. These test programs not only determine whether a finished structure meets specifications but also show which load ratings may be increased and provide a means by which new materials and methods of construction may be compared with proved designs.

Values and Procedures of AMC's Structural Testing Program. W. B. Miller. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 22, November 15, 1948, pp. 19–25, illus.

The Air Materiel Command has the equipment and facilities for testing entire air-frame structures. About 70 critical tests are performed to ensure that the prescribed design ultimate loads can be sustained by an aircraft and to discover overstrength components that impose unnecessary weight penalty. Successive structural modification and retesting ensure that proper allowances have been made for structural changes, substitutions of materials and construction methods, and stress-analysis assumptions. A typical program is illustrated by the series of tests performed on a C-47.

Effect of Bending Rigidity of Stringers Upon Stress Distribution in Reinforced Monocoque Cylinder Under Concentrated Transverse Loads. R. S. Levy. **Discussion.** M. Z. Krzywoblocki. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, p. 388. 3 references.

Critical Shear Stress of Plates Above the Proportional Limit. George Gerard. **Discussion.** E. Z. Stowell. Walter Ramberg. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 386, 387. 4 references.

Letters to the Editor: Note on "Statistical Aspects of Fracture Problems." Franklin H. Fowler. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, p. 1092. 1 reference.

Dynamic Calibration Method Uses Modified Proving Ring. R. C. A. Thurston. *American Society for Testing Materials, Bulletin*, No. 154, October, 1948, pp. 50–52, illus., diagr. 4 references.

Some Thoughts About Weight. L. W. Rosenthal. *The Aeroplane*, Vol. 75, No. 1953, November 12, 1948, p. 615.

Thermodynamics (18)

Thermodynamic Properties of Gas Mixtures Encountered in Gas-Turbine and Jet-Propulsion Processes. Joseph Kaye. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 349–361, diagr., tables. 8 references.

The presentation of data for gas mixtures on a molal basis reduces greatly the number of gas tables required for calculations of processes in a wide variety of mixtures. This simplification of the tabular data is illustrated by consideration of several gas mixtures and of the processes encountered in the design of gas turbines. Three tables of products of combustion of a hydrocarbon fuel with air are sufficient to permit calculations of all processes of interest, with an average error of about 0.1 per cent over a large range of hydrogen-carbon ratios of the fuel-air ratios for lean mixtures. These three tables may be used with the same error for calculations involving mixtures of air and octane vapor, as well as for mixtures of air and water vapor.

An Observation on Heat Sources Placed at Random on a Surface. Gregory H. Wannier. *Journal of Applied Physics*, Vol. 19, No. 11, November, 1948, pp. 1020–1022. 1 reference.

A mean-value theorem and a fluctuation theorem for the case in which a potential is attributable to sources of potential disposed at random on a surface. By evaluating the potential for the actual geometry with a smooth source function and by introducing local irregularities as an erratic source function that averages out to zero in an extremely small area, formulas are obtained which, when applied to the heat caused by the friction of two solid surfaces between which point contact is assumed, give results essentially the same as those obtained by Holm, who used as a model a surface on which heat was evolved in circular spots.

Heat Transfer Through Thick Insulation on Cylindrical Enclosures. T. S. Nickerson and G. M. Dusinberre. *American Society of Mechanical Engineers, Transactions*, Vol. 70, No. 8, November, 1948, pp. 903–906, figs. 3 references.

A graph is constructed for finding the heat transfer through relatively thick insulation applied to an enclosure having the form of a short cylinder such as a tank. Incorrect treatment of the corner effect in this case may lead to serious error. The relaxation method of calculation was used.

Heat-Exchanger Tube-Sheet Design. K. A. Gardner. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 377–385, diagrs., figs. 8 references.

Water-Borne Aircraft (21)

Note on Design of Flying-Boat Hulls. F. W. S. Locke, Jr. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 22, November 15, 1948, pp. 15–18, diagrs., fig.

Model tests conducted in the Experimental Towing Tank of the Stevens Institute of Technology showed that, for flying boat hulls of equal seaworthiness, increasing the length beam ratio improved both the hydrodynamic and aerodynamic characteristics. Changes in the dimensions and load coefficient gave hulls with different take-off, spray, and range characteristics and thus allowed the forebody proportions to be selected specifically for the special purpose for which a flying boat is designed. The afterbody is an appendage that provides buoyancy at low speeds and, at the hump, supplies a moment that controls the trim of the forebody. The high-speed characteristics of the afterbody are improved by making it slender. Its optimum length depends on the purpose of the craft.

Wings Under Water. *Flight*, Vol. 54, No. 2080, November 11, 1948, pp. 561–563, illus., diagr. Description and performance of the Hook Hydrofin HN-4, a marine craft that is kept automatically at constant draft by variable incidence hydrofoils that are controlled, through a system of levers, by surface skids running in advance of the craft.

Wind Tunnels (17)

Stability Derivatives: Determination of I_p by Free Rolling. J. M. Evans and P. T. Fink. *Australia, Council for Aeronautics,*

STAINLESS STEEL HELICOPTER BLADES—a recent development for all-weather flying operations. Flight tests indicate that stainless steel rotary wings have lifting characteristics superior to conventional blades and may be flown safely in light or heavy rains. Because they are made of stainless steel, these blades are very light in weight, yet they offer maximum resistance to distortion under heavy load.

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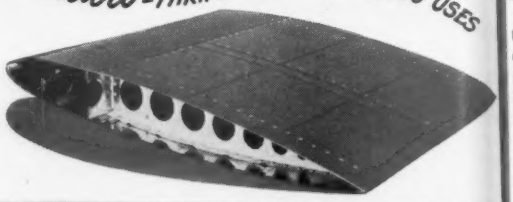

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Report No. ACA-35, May, 1947. 23 pp., illus., diagrs., figs. 17 references.

A free-rolling method for determining the rolling derivative due to rate of roll from the mean angular velocities of the model in two directions. Inertia moments resulting from bearing friction and tunnel-wall interference and the inertia moments introduced by the nonuniformity of the rolling motion are taken into account by a simple experimental technique. The method is restricted to lift coefficients below the stall and to rolling about a wind axis. Results obtained in two different wind tunnels with a 1/10th scale model of the Boomerang single-engined fighter showed that, at small lift coefficients, the rolling derivative due to rate of roll was independent of the combined effect of the rate of roll and the angle aileron angle if the ailerons were not stalled. Below the stall the value of the derivative at first increased rapidly with the lift coefficient, then became constant, and thereafter decreased. No scale effect was observed on the wing alone at Reynolds Numbers between 160,000 and 800,000. In this range, some scale effect was found for the complete Boomerang model which caused the derivative to decrease as the Reynolds Number increased. Lifting-line theory gave a value of the stability derivative at a lift coefficient of 0.25, which was 4 per cent higher than that measured. It was not possible to predict from lifting-line theory the observed variation of the derivative with the lift coefficient.

High Capacity Eddy Current Coupling. *Product Engineering*, Vol. 19, No. 11, November, 1948, pp. 96, 97, illus., diagrs., figs.

The use of a special magnetic alloy to produce stronger eddy currents and interlacing field poles give the variable-speed eddy-current wind-tunnel fan coupling built by the Dynamic Corporation a smooth torque-speed curve with maximum torque at maximum slip speed. Diagrams show the electronic circuits that can be used to control the coupling for constant speed or constant torque. It can transmit 18,000 hp. at 485 r.p.m.

Trends in the Application and Maintenance of Turbojet Engines

(*Continued from page 47*)

gine and accessories for quick servicing or replacement and, at the same time, avoiding the penalty of mutual interdependence. The power-plant change problem becomes severe when the engine is loaded with auxiliary devices requiring appreciable space and many connections.

Only when the users of the engines, as well as the engine and accessory builders, recognize the pronounced trend toward complication and act accordingly to preserve the inherent simplicity of the turbojet will further development continue in a healthy manner.

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Sixth Personal Aircraft Meeting—Hotel Allis, Wichita, Kan.—April 29–30

Second Joint I.A.S.-R.Ae.S. Conference—New York—May 24–26

Annual Summer Meeting—Los Angeles—July 21–22

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

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Aeronautical Reviews

Books

Advanced Dynamics

By S. Timoshenko and D. H. Young. New York, McGraw-Hill Book Co., Inc., 1948. 400 pp., illus., diagrs. $5.50.

A gap exists in the teaching and literature of dynamics between the almost elementary mechanics that the engineering student learns in freshman and sophomore courses and the advanced theoretical dynamics of Lamb, Routh and Webster and of the books on theoretical physics for first-year graduate students. It is all the more important that this gap be bridged today when dynamics has become so essential in the study of high-speed machinery, vibration theory, balancing, aircraft dynamic stability, ballistics, and rocket flight, to mention but a few modern topics. There is no better man in either hemisphere to bridge this gap than Professor Timoshenko, and he has a good partner in his scholarly and experienced colleague, Professor Young. The *Advanced Dynamics* meets almost all expectations. It is an advanced book, probably suitable for graduate students only, and does not dodge mathematical difficulties but meets these difficulties well and relates theory to the solution of practical problems. Thus, in Chapter I, the classical treatment of Dynamics of a Particle leads to the solution of practical problems in vibration, in the motion of a projectile, and in other ballistic problems. Similarly, in Chapter 2, Dynamics of a System of Particles, the classical equations lead to useful applications in rockets, impact, engine balancing, and the theory of rotating machinery. With 150 problems judiciously spread throughout the book, this is precisely the way a subject should be taught, and what are textbooks for except for teaching, which includes self-teaching? Chapter 3 on Dynamics of Systems with Constraints deals soundly with generalized coordinates and Lagrange's equations and robs this difficult topic of a good deal of its terror. In Chapter 4, Theory of Small Vibrations, we find precisely those problems that worry aeronautical engineers today, such as systems with several degrees of freedom, the calculation of principal frequencies, vibration about a steady state of motion, etc. Chapter 5, Rotation of a Rigid Body About a Fixed Point, gives a sound introduction to gyroscopics and gyroscopic stabilization. The book suffers, perhaps, from one defect. It is, with its 400 pages, a wonderful year's work for a graduate student in mechanical or aeronautical engineering, but it is a trifle short for the practicing engineer who would like a little more of everything, more about nonlinear vibration, more about rigid dynamics with moving axes, etc. But the practicing engineer will nonetheless delight in a sound, compact volume of principles, and what one book, after all, can cover the enormous range of applications that advanced dynamics has in the fields of modern scientific engineering?

DR. ALEXANDER KLEMIN
Consulting Engineer

Rocket Development

Liquid-Fuel Rocket Research, 1929–1941

By Robert H. Goddard. Edited by Ester C. Goddard and G. Edward Pendray. New York, Prentice-Hall, Inc., 1948. 291 pp., illus. $6.50; $4.90 to schools.

This book consists of excerpts from the notebooks of the late Dr. Robert H. Goddard in which he recorded his experiments with liquid-fuel rockets undertaken during the period from 1929–1941. As is well known and has often been remarked upon, Dr. Goddard published virtually nothing during his lifetime, and any estimate of his work had to be based upon his two short and sketchy Smithsonian reports and some 60 patents. The present book is designed to shed some light on the experimental work he performed, mostly in New Mexico, and especially during the period following the second Smithsonian report of 1936.

The two editors state in an introduction that at the time of Dr. Goddard's death the following material (in addition to several complete rockets, rocket motors, and other parts) was available to them: (1) one set of early notebooks covering the period from 1899 to 1910; (2) one set of notebooks containing ideas, later mostly embodied in patents, from the period 1924 to 1942; (3) one set of notebooks describing the experiments from 1920 to 1943, comprising 5,500 typewritten pages, 2,600 photographs, and 500 pages of sketches and drawings; (4) a set of reports to the Smithsonian Institution and The Daniel and Florence Guggenheim Foundation; (5) several book-length manuscripts and a condensation from his notes; (6) papers on 70 patents and notes for an additional 100 patents applied for by his executor; and (7) 3,000 photographs, films, etc. The material comprising the present book consists of the condensed notes listed under (5).

Dr. Goddard's work fell into four clearly distinct phases. The first phase extended from 1899, when the then 17-year-old student made his first notes, until the end of World War I, in the course of which he made experiments with solid-fuel rockets. The second phase was that financed by the Smithsonian Institution and Clark University, lasting from 1919 to 1929, during which time the first experiments with liquid-fuel rockets were made. The third phase was the period from 1929 to 1941, financed mostly by Daniel Guggenheim and by the Guggenheim Foundation. The fourth phase was Dr. Goddard's work at Annapolis from 1941 until his death on August 10, 1945. This fourth phase is still classified matter, but a rather detailed outline of the work during the second and third phases is now available.

The shot-by-shot and experiment-by-experiment reports taken from Dr. Goddard's notebooks with apparently no editing will make interesting reading, especially to the working experimenter or to the young engineer who intends to devote his later life to rocket experimentation. In Dr. Goddard's work on gyrostabilizers and on fuel pumps, it seems to this reviewer that many of the difficulties encountered would have been almost automatically avoided if he had only been able to go to a larger size. It also seems as if the problem of cooling the motors was never completely mas-

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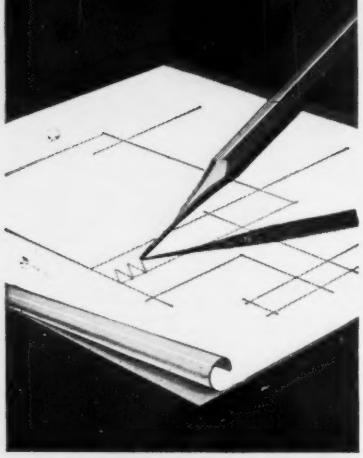

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The publication of this book, with its careful documentation of an important and hitherto unknown chapter in the history of rocket research, has at long last filled a gap in the rocket section of technical libraries.

WILLY LEY
Research Engineer,
Washington Institute
of Technology, Inc.

Book Notes

ELECTRONICS

Principles of Radar. Denis Taylor and C. H. Westcott. Cambridge, at the University Press; New York, The Macmillan Co., 1948. 141 pp., illus., diagrs., figs. $3.50.

An introduction to the technical aspects of radar design and employment for engineers, physicists, and advanced students. Knowledge of electromagnetic theory, usual radio practice, the calculus, and the $j(=\sqrt{-1})$ convention are requisite for a full understanding of the principles explained. The mathematical portions of the text are introduced only after clear and comprehensive explanations of the theory and practical problems involved. Contents are: The Generation and Reception of Pulse Modulated Systems; Factors Affecting the Performance of a Radar Equipment; Radar Ranging; The Determination of Azimuth; The Determination of Elevation; Systems for Determining Both Azimuth and Elevation; Unwanted Echoes; Electrical Characteristics of Typical Radar Equipments; and Secondary Radar. There are two appendixes: Glossary of Symbols and Standard Formulae; and The Calculation of Absorbing, Scattering and Echoing Areas. The book is well indexed, and there are numerous block diagrams, graphs, and line drawings depicting cathode-ray tube displays. Reference to other works are made occasionally in the text and in footnotes. Dr. Taylor is Superintendent of the Telecommunications Research Establishment (T.R.E.) of the British Ministry of Supply, and Dr. Westcott is with the Physics Department of Birmingham University and was formerly Senior Scientific Officer of the T.R.E.

Microwave Antenna Theory and Design. Edited by Samuel Silver. (Massachusetts Institute of Technology, Radiation Laboratory Series No. 12.) New York, McGraw-Hill Book Company, Inc., 1949. 623 pp., illus., diagrs., figs. $8.00.

The principal types of antennas considered are pencil-beam antennas and antennas for toroidal and flared beams for use in that part of the spectrum extending from 0.1 to 25 cm. Antenna patterns, microwave beams and transmission lines, radiating elements, and impedance characteristics comprise, in general, the main topics. The treatment of developments in theory and of the solutions to practical problems in mathematical is based chiefly on work done during World War II at the M.I.T. Radiation Laboratory. The principles of electromagnetic theory and physical optics receive detailed treatment so that the antenna engineer may use this knowledge as a basis for design. The text is documented with numerous footnote references to books, periodical articles, and *Radiation Laboratory Reports*. There is a detailed table of contents and a 9-page index. Aircraft-antenna and radome problems are the main topics handled in Chapter 14, Antenna Installation Problems. Contents: Survey of Microwave Antenna Design Problems; Circuit Relations, Reciprocity Theorems; Radiation from Current Distributions; Wave Fronts and Rays; Scattering and Diffraction; Aperture Illumination and Antenna Patterns; Microwave Transmission Lines; Microwave Dipole Antennas and Feeds; Linear Array Antennas and Feeds; Waveguide and Horn Feeds; Dielectric and Metal-Plate Lenses; Shaped-Beam Antennas; Antenna Installation Problems; Antenna Measurements—Techniques; Antenna Measurements—Equipment.

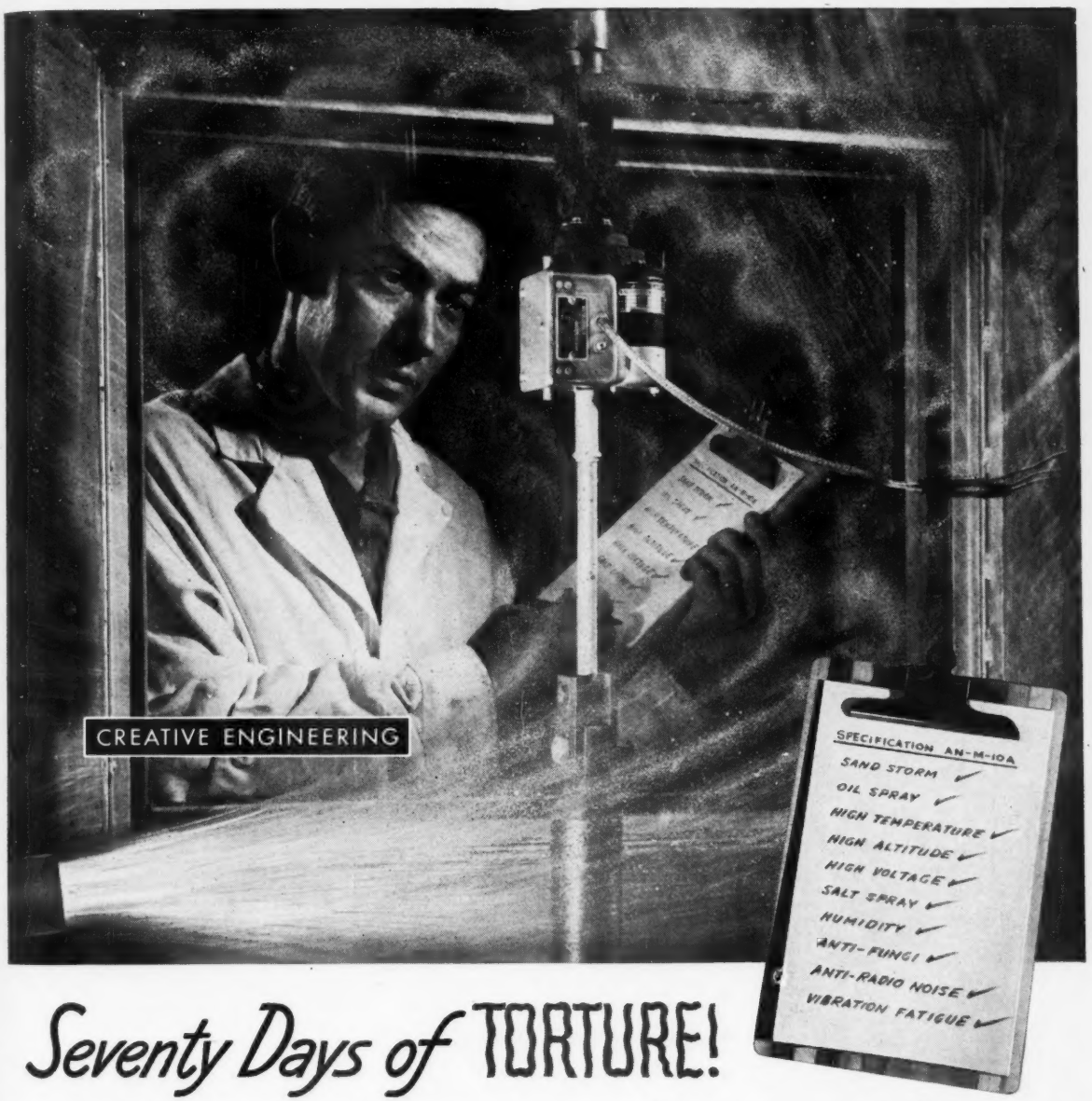
Velocity-Modulated Thermionic Tubes. A. H. W. Beck. Cambridge, at the University Press; New York, The Macmillan Co., 1948. 180 pp., figs. $3.75.

The developments in velocity-modulation tubes since 1939 are given principal emphasis. It is assumed that the reader is familiar with prewar radio theory and technique and its mathematical aspects. The manuscript was completed April, 1946, but it has been brought up to date by the inclusion of the appendix on the traveling-wave tube and the addition of references to literature published during the next year. The author, who is with the Standard Telecommunication Laboratories and was formerly Senior Temporary Scientific Officer with the British Admiralty, has made use of both published and unpublished data compiled by British and American companies and governmental research agencies. Contents: Chapter 1, The Elementary Principles of Velocity-Modulation Tubes; Chapter 2, Cavity Resonators; Chapter 3, The Theory of Velocity Modulation; Chapter 4, Heavy Current Electron Beams; Chapter 5, Velocity-Modulation Amplifiers and Frequency Multipliers; Chapter 6, Klystron Oscillators; Chapter 7, Reflex Klystron Oscillators; Chapter 8, Miscellaneous Types of Velocity-Modulation Tube; Chapter 9, Limitations and Defects in Velocity-Modulation Tubes; and Chapter 10, The Design Requirements and Manufacture of Velocity-Modulation Tube Components. The material in Chapters 3 and 5 to 8 comprises, in importance, the major part of the book. The book closes with: two appendixes, one on an example of the design of a high-powered c.w. klystron, and the other on the traveling-wave tube; five brief tables of performance and design variables, calculated to slide-rule accuracy; a list of symbols; a bibliography of six text books and three papers that are not mentioned in the text; and a subject index of a little more than a page. All formulas are given in m.k.s. units.

MODEL AIRPLANES

Performance and Longitudinal Stability of Jet Propelled Aircraft, With Special Consideration of Flying Airplane Models. P. Bielkowicz. London, Alma Book Company Ltd., 1947. 79 pp., diagrs., figs. 8s.

The theory of longitudinal stability is applied to a model jet aircraft to illustrate a complete treatment of a flying model. The presentation of the theoretical portions of the book presupposes only an understanding of the simplest fundamentals of differentiation and integration. In their final shape, the formulas that are derived can be used by readers unacquainted with calculus. The ram-jet and the resonance-types of jet engine are considered. Principal attention is given to the ram-jet model because of the difficulties presented by the high launching speed it requires. A general pattern of calculations is outlined which can be applied to the resonance model and is equally appropriate for designing propeller-powered aircraft. Tables and graphs are included in the text and a bibliography. Eleven references to books, *N.A.C.A. Reports*, and the *Journal of the R.Ae.S.* are appended.



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NAVIGATION

The Computation of Orbits. Paul Herget. University of Cincinnati, Cincinnati, Published privately by the Author, 1948. 177 pp., figs. $6.25.

The textbook is for both students of astronomy and students of mathematics. It was developed from the lectures by the author, who is Professor of Astronomy at the University of Cincinnati Observatory, and Director of the Cincinnati Observatory, on orbit computation.

All formulas and precepts have been prepared for use with a modern hand-operated, desk-model, calculating machine. The orbits of minor planets are treated before the orbits of comets because they require a minimum of theory and solutions can be obtained more readily. The student is assumed to be familiar with differential and integral calculus but not with the calculus of finite differences, to which an entire chapter is devoted. A second preliminary chapter states the problems in spherical astronomy before the problem of two bodies is taken up. Succeeding chapters contain the method of La Place and the methods of Gauss and Olbers for the computation of the orbit and the ephemeris of a newly discovered object in the solar system, improvement of the calculated orbit, and the accommodation of special perturbations. Finally, a simple outline is given of the Method of General Perturbations of Hansen, and each step in the computations is described in detail. The material has been arranged in a continually unfolding psychological order rather than in a strictly logical order, and each method is introduced in a setting that shows and describes the manner in which it was discovered, including all the pitfalls and futile attempts. Tables are included for sines and cosines, argument in "circles," topocentric corrections, Everett's coefficients (critical table), nearly parabolic motion, interpolation of integration tables, and inverse cube. Literature is cited throughout the text, and there is a combined index of names and subjects.

PRODUCTION

Design for Welding. Robert S. Green, Editor. Cleveland, The James F. Lincoln Arc Welding Foundation, 1948. 1024 pp., illus., diagrs., figs. $2.00.

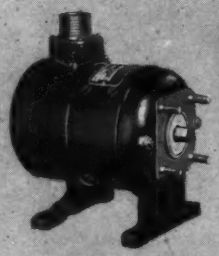
A compilation of 82 papers on arc-welding design and practice which received awards from The James F. Lincoln Arc Welding Foundation. Six papers are of direct interest to aeronautical engineers: Development of Arc Welded Propeller Hubs, Douglas W. Hamilton, Clarence C. Mast, and Paul F. Hackethal; Arc Welded Assembly of the B-36 Engine Mount, E. C. Constantino; Aircraft Landing Gear Support Weldment, Richard C. Findeiss; Arc Welding of Wing Attachment Strut on Postwar Personal Airplanes, Sherman S. Graves and E. E. Rippey; Arc Welding of Landing Gear Dollies for Aircraft Maintenance, George Habian; and Designing a Welded Aircraft Seat with Magnesium, Peter G. Poetto.

SCIENCES, GENERAL

MATHEMATICS

Practical Analysis; Graphical and Numerical Methods. Fr. A. Willers. Translated by Robert T. Beyer. New York, Dover Publications, Inc., 1948. 422 pp., illus., diagrs., figs. $6.00.

A considerable amount of the research sponsored by aeronautical establishments during recent years has been devoted to the practical solution of the mathematical formulas that have been developed in the course of studies of airfoils, flow fields, flight mechanics, and other phases of aeronautical theory. Mathematical terms, concepts, and techniques have therefore come more and more to the attention of workers connected with aircraft research and design. This book, translated from the German, discusses the numerical, graphic, and instrumental solution of mathematical problems and affords an integrated presentation of many methods that are often not clearly understood, except by the mathematician, and for which fundamental explanations are frequently hard to find. The first chapter deals with the problem of calculating with approximate numbers and discusses the theory accuracy and relative value of such mechanical aids as tables, graphs, nomograms, and mechanical computers. The section on the slide rule has been rewritten to correspond with the American, rather than the continental, instrument. The section on calculating machines in the original text has been replaced by a new monograph by Treacy W. Simpson to reflect current methods with American-made calculators and includes an extensive outline of their application. The second chapter contains the standard methods of interpolation; the third, methods of approximate integration and differentiation. The fourth chapter takes up the practical determination of the roots of single algebraic equations and systems of linear equations, and the fifth deals with empirical formulas and curve fitting. The sixth chapter includes methods of graphic and numerical integration of differential equations. The original work, written in 1928, has become universally recognized for its completeness, its careful evaluation and comparison of the various methods, and its well-balanced treatment. The author presupposes that the reader has a background in advanced mathematics. Although his text must be read slowly and with attention because of the nature of the subject matter, the author has presented his material with such clarity that it can be read with profit by a person with limited mathematical training. It has not been practical to compare the translated text with the original. The English is simple, idiomatic, and not marred by "foreignisms." The diagrams, for the most part, are reprints of those in the original volume and have suffered somewhat in the reproduction. References are listed at the ends of chapters. There is a subject index and an index to authors cited.



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I.A.S. Sections

(*Continued from page 21*)

for turboprop engines and as rocket flight path simulators for the solution of equations of motion of a rocket. Electronic computers also may be used for analysis instead of synthesis—i.e., determine the required initial design data for a given end result. Total differential equations are capable of solution by electronic computers; however, partial differential equations remain a great problem.

Chicago Section

A. J. Mooers, *Secretary*

H. V. Hawkins, Professor of Civil Engineering at Illinois Institute of Technology, Chicago, was elected Chairman of the newly organized Section at a meeting January 11. Approximately 115 members attended.

▸ **Other Posts Filled**—Other officers chosen were: Vice-Chairman, K. L. Burroughs, Vice-President of Aeronautical University; Secretary, A. J. Mooers, Aerodynamicist, Ordnance Research Division, University of Chicago; Treasurer, R. H. Wendt, Chief Engineer, Aircraft Division, Globe Corporation; and Representative to Nominating Committee for Area Councilors, C. N. Lusty, Assistant Chief Engineer, Aircraft Division, Globe Corporation.

Members of the Advisory board are R. O. Brittan, C. F. Eck, R. S. Hartenberg, H. L. Hull, W. A. Klikoff, T. G. Linnert, F. A. Rappleyea, and R. G. Urquhart.

Dr. J. T. Rettaliata, Dean of Armour College of Engineering, Illinois Institute of Technology, gave a talk on "Jet Propulsion," with which he showed slides illustrating gas-turbine fundamentals, pictures of successful jet aircraft, and the comparison between jet and reciprocating engines.

Dayton Section

William A. Barden, *Secretary*

The joint meeting January 18, at which the Dayton Section members were guests of the Dayton S.A.E. Section, featured Mr. Andrew Kalitinsky, Chief Power Plant Engineer, NEPA Project, Oak Ridge, who spoke on "Atomic Power and Aircraft Propulsion."

▸ **Unlimited Range**—Mr. Kalitinsky said that atomic energy as a source of power for aircraft promises to achieve results unobtainable by standard fuels—airplanes combining extremely high speed with almost unlimited range.

PLANNING TO MAKE I.A.S. HISTORY

On January 9, 1949, all officers and committees of the Los Angeles Section met to chart their share of the West Coast's biggest year. With the new western headquarters building to be available for the Annual Summer Meeting July 21–22, Chairman Joe Barfoot and his cohorts have big plans for outstanding meetings, field trips, building dedication, and new membership.

"We have not manufactured an atomic power plant for aircraft," said Kalitinsky, "but we can say that the practical development of atomic energy as a source of power calls for the active cooperation of both scientists and engineers in research institutions and industry if an early and successful application of this power is to be made."

▸ **High Temperature Problem**—According to Kalitinsky, many of the problems confronting the practical realization of atomic aircraft power plants are connected with the attendant high temperatures. Unlike chemically fueled engines, high thermal efficiency is not the primary reason for wanting high temperatures in a nuclear engine. The temperature problem is aggravated by the heat transfer problem.

The engine component of the nuclear installation, Kalitinsky said, may be expected to weigh the same as a conventional power plant of the same horsepower or thrust rating. The weight of the reactor shielding is therefore equivalent to the weight of the fuel and fuel tanks in chemically powered aircraft.

Detroit Section

Henry H. Kerr, *Secretary*

At the Section's January 6 meeting, members heard Walter E. Jominy, Staff Engineer of Chrysler Corporation, on the topic of "Some Modern Concepts in the Selection of Materials." Chairman Robert Dale presided with 20 members present.

Philadelphia Section

J. Albert Ray, *Secretary*

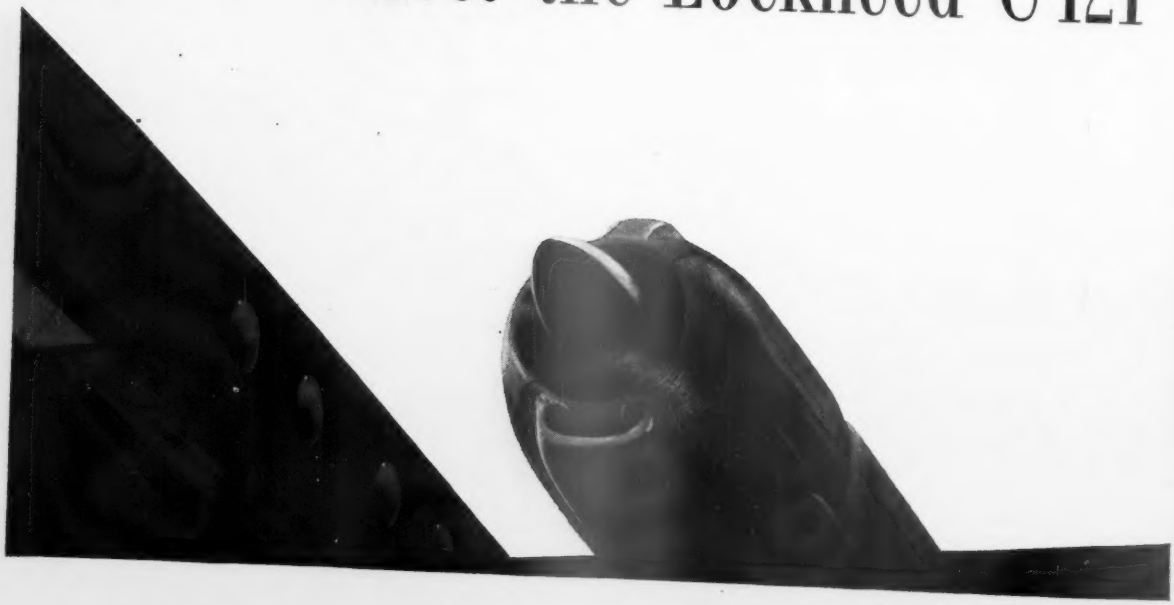
Members attending the December 2 meeting heard Lt. Comdr. George W. Hoover, U.S.N., on the subject of "Consideration of the Human Element in Cockpit Design."

▸ **Best Insurance Policy**—Commander Hoover, who is head of the Flight Section of the Special Devices Center, Sands Point, Long Island, N.Y., has worked on standardization of fighter cockpits for Naval aircraft. He said Americans stand on the threshold of a new era, the age of supersonic flight. Upon their crossing that threshold, Commander Hoover said, may depend the security of this nation, for air power is clearly our best insurance policy, either for maintaining peace or for winning another war.

Supersonic flight will require supersonic pilots, he said. Human reaction time has become a No. 1 consideration in the design of any man-operated equipment. The pilot of the future may, in effect, be merely the brain carried to the scene of action in order to make tactical decisions. The flight of the aircraft itself must be almost fully automatic.

Such a program is possible and is, Commander Hoover concluded, at the present time under research and development.

Meet the Lockheed C-121*



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San Diego Section

William T. Immenschuh, *Secretary*

The December 3 joint dinner-meeting with the S.A.E., attended by 130 members, was presided over by William Clegern of the Program Committee.

▸ **Cold Subject**—Principal speaker was George Q. Noville, an explorer and former officer in the Navy and Air Force, who spoke on "Cold Weather Operations."

Mr. Noville, who was advance officer for U.S. Army's "Around the World Flight" 1923–1924, and Executive Officer on the Byrd North Pole Expedition, 1925–1926, and on the Byrd Antarctic Expedition, 1932–1934, in addition to many other notable achievements in flight and exploration, spoke of early attempts to utilize World War I aircraft for airmail services and the problems encountered under cold weather conditions.

Movies were shown of flight trials and the take-off of the Fokker airplane, America, in which Admiral Byrd crossed the Atlantic and in which Mr. Noville was copilot and flight engineer, and of the early Arctic expeditions and 1932–1934 Antarctic expedition in considerable detail.

Seattle Section

Robert M. Robbins, *Secretary*

Dr. K. C. Clark, Professor of Physics, University of Washington, spoke at the December 14 meeting on the subject, "The Upper Atmosphere."

▸ **Nature Helps**—Dr. Clark discussed in nontechnical language the methods used to study the upper atmosphere and how some of nature's phenomena assist greatly in this exploration.

At the lower altitudes, below about 70 miles, airplanes, balloons and V-2 rockets permit direct observations. At heights from 40–70 miles, incandescent meteors traveling from 10,000 to 40,000 m.p.h. are the source of much information, while in the 80–200-mile altitude range the aurora borealis is a major source of knowledge.

▸ **Sun Bombardment**—Northern lights, said Professor Clark, are caused by the bombardment of our outer atmosphere with particles from the sun. Because of the stronger magnetic fields near the poles of the earth, the bombardment is more concentrated in these regions.

Washington Section

Ralph F. Broberg, *Secretary-Treasurer*

Speaker of the evening at the December 1 meeting, at which Milton Ames was introduced as the new Chairman by Ivan Driggs, Past-Chairman, was Melvin N. Gough, Chief of the Langley Flight Research Division of N.A.C.A.

▸ **Supersonic Problems**—Mr. Gough discussed some of the organizational and operational problems that have arisen in the development of a supersonic flight research test program. The requirements and background of a supersonic research test pilot were outlined, and the pilot's contribution to the success of the program were explained. Mr. Gough emphasized the basic similarity between the subsonic and supersonic research pilot's position.

Films of the Bell X-1 were shown at conclusion of the talk.

Wichita Section

H. E. Dickard, *Secretary*

The section held its monthly dinner meeting on December 2 with 35 present at the dinner and an additional number after dinner. Elton H. Rowley, Chairman, presided.

▸ **High Lift Device**—A paper, "External Airfoil as a High Lift Device," was given by Doug Heimberger of the Boeing-Wichita Flight Test Section. Author of the paper was Earl Weining, Project Engineer of Boeing.

Wilfred Pearce, Treasurer, gave a financial report.

News of Members

Group Capt. D. F. Anderson, R.A.F. (ret.), is Vice-President in Charge of Production, Fiberlast of Canada Ltd. He lives in Camden, Me.

Richard Archbold is President of the Archbold Biological Station at Lake Placid, Fla.

Hall E. Beatty is Senior Detailer at McDonnell Aircraft Corporation.

Charles T. Boehnlein resigned from Douglas Aircraft, Santa Monica, where he was a Design Specialist, to become a Lecturer in Engineering at University of California at Los Angeles.

Alan R. Bott, former Lieutenant (j.g.), U.S.N., is now at Doman-Frasier Helicopters, Inc., as Director—Flight Engineering Research.

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ROMEC PUMP APPOINTEE

Andrew F. Haiduck has been appointed General Manager and Chief Engineer of the Romec Pump Company Div., Lear, Inc., at Elyria, Ohio. Mr. Haiduck assumes new responsibilities after two years with Fairchild Engine & Airplane Corp., Farmingdale, L.I., part of which time he was General Manager of the Duramold Division.

Henry L. Brownback has been made a Chevalier of Legion of Honor by the President of France for scientific and engineering work he had done in France.

Paige B. Burbank is an Engineer with the National Advisory Committee for Aeronautics, Langley Field, Va.

H. H. Cherry was recently appointed Assistant Professor and Research Assistant in the Department of Aeronautical Engineering at Texas A. & M. College. He came to the college from Douglas Aircraft in Santa Monica, where he was Preliminary Design Engineer for the past 3 years.

A. C. Coffman is General Manager with the Chamberlain Engineering Corporation, Division of U.S. Stoneware Company.

Joseph J. Dysart has been promoted to Maintenance Manager, Pan American World Airways, at Miami.

William H. Ehmcke, formerly Flight Test Engineer at Convair, now is in the W. G. Ehmcke Sheet Metal Works as an Estimator.

Joseph P. Fay, formerly Engineering Design Checker at Convair's Ft. Worth, Tex., plant, now is Structural Design Engineer for H. L. Yoh Company, Inc., at Northrop Aircraft, Hawthorne, Calif.

Forest W. Fingerle moved to San Diego where he is Engineering Designer B at Consolidated Vultee Aircraft.

R. T. Goodwin, formerly Head of the Aviation Department, Shell Oil Company, has been named Manager of Shell's Special Products Department.

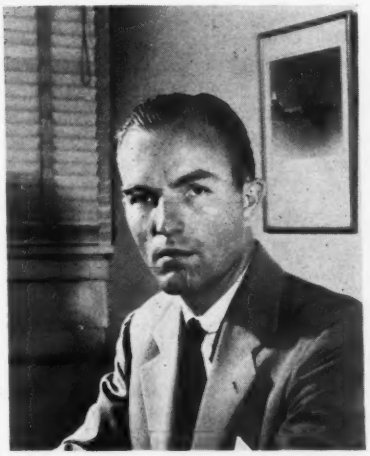
J. I. Hamilton is Project Manager with Frederick V. Lawrence, Inc. He had been with Propeller Division, Curtiss-Wright Corporation, as Assistant Sales Manager.

Adolph M. Hanson is Layout Draftsman at McDonnell Aircraft Corporation, Robertson, Mo.

E. G. Havard, who is in the Performance Section, Rolls-Royce Ltd., Hucknall Aerodrome, No. Nottingham, England, has been elected an Associate Fellow of The Royal Aeronautical Society.

Stanley Hiller, Jr., has announced the price tag of the recently licensed Hiller 360 helicopter to be $19,995 f.a.f., Palo Alto. Distributor deliveries began in February. United Helicopters, of which Hiller is President, has facilities to produce two 'copters a day when full production is achieved.

Rudolph A. Johnson is under "lend-lease" contract to Boeing Airplane Company (Seattle) from Curtiss-Wright (Columbus).



AIR-LINE OPERATIONS ENGINEER

Carl F. Schmidt's appointment to the new position of air-line operations engineer announced by Lockheed Aircraft revealed an innovation in the company's customer service program. A member of Lockheed's Engineering Flight Test Division since 1941, Schmidt worked on the Connie program since early flight-test days nearly 6 years ago. He was closely associated with A.T.C. during introduction of the C-69 at war's end and spent some time in the field assisting air-line operators in working out early operational problems.

Charles H. Kaman was named Chairman of the Board, President and Treasurer of Kaman Aircraft Corporation, at the company's annual stockholders meeting. Kaman also has been appointed to N.A.C.A. Subcommittee for Aeronautics on Helicopters.

Vincent F. Lopresti is with Standard Engineering, Inc., Plainfield, N.J., as Field Engineer assigned to the U.S. Navy.

William G. McCamant is Engineer B, Aerodynamics, Boeing Airplane Company, Seattle.

Andrew C. McDermott has moved from Chicago to 1226 S. 140th St., Seattle, Wash., where he is employed by Boeing Airplane Company.

Albert De Neufville is an Instructor in Mechanics at Lehigh University.

William D. O'Brien is attending Harvard Graduate Business School and expects to return to the aircraft industry following completion of the course.

Carl M. Onspaugh is now living at 28 Lawn St., Dayton, Ohio. He is Flight Test Engineer in the Engineering Performance Section of the Flight Test Department at Wright Field and is assigned to the B-36 Project assisting in the daily reduction of flight-test data, acting as engineering observer on test flights, and assisting in compilation of results and data obtained.

Werner Pfenninger, of Switzerland, has joined Northrop Aircraft, Inc., Hawthorne, Calif. New address is 443 West 118th St., Hawthorne, Calif.

Ralph E. Sliney, Jr., is at Wright-Patterson Air Force Base in the Flight Data Branch, Aircraft Projects Section, Engineering Division, Air Materiel Command.

John E. Soenke is Dayton Representative for The Glenn L. Martin Company. He formerly was Business Manager, Commercial Airplanes, for Martin.

Lt. Col. Charles T. Stoffer, formerly Inspector General, Flight Service, M.A.T.S., is now Executive Officer at the Goose Bay, Labrador, Air Force Base.

James E. P. Sullivan, Laboratory Engineer for Chrysler Airtemp, Dayton, was appointed to a 5-year term on the Dayton Plan Board by the Dayton City Commission. He also is a member of the governing board of the S.A.E. and the inventor of several patents on military aircraft.

Robert K. Wattson, Jr., is Associate Professor of Mechanical Engineering and Head of the Aeronautical Engineering Section, North Dakota Agricultural College. In the December REVIEW, Mr. Wattson had been named Assistant Professor by error.

HEADS SHELL AVIATION

Joseph S. Harris, formerly Assistant Manager of Shell Oil's Aviation Department, with headquarters in New York City, has been named Head of the Department. An M.I.T. grad, he has been with Shell since 1930, when he started as research man in Technical Products Department.

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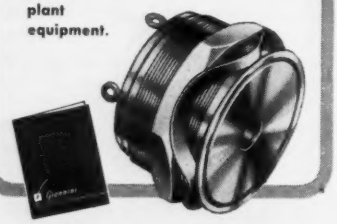

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A. J. Wittenbach, Jr., is Flight Test Analyst at McDonnell Aircraft Corporation, Robertson, Mo.

W. H. Womer has been made Development Engineer at the International Resistance Company, Philadelphia, manufacturers of radio resistors. Mr. Womer previously was Design Engineer.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Zucrow, Maurice J., Ph.D., Professor of Gas Turbines & Jet Propulsion, Purdue University.

Transferred to Associate Fellow Grade

Winchester, James Eugene, Commercial Engineering Sales, Airplane Div., Curtiss-Wright Corp.

Elected to MEMBER Grade

Bitner, James Vincent, Jr., B.M.E., Layout Designer, The Glenn L. Martin Co.

Buck, Robert N., Capt., International Div., T.W.A., Inc.

Calhoun, John Thompson, B. of M.E., Group Leader, Fuselage & Equipment Analysis, Beech Aircraft Corp.

Culbertson, Allman T., Col., U.S.A.F.; Chief, Cargo Branch; Acting Chief, Aircraft Projects Section, Engineering Div., Air Materiel Command, Wright-Patterson Air Force Base.

Felberg, Fredrick Hartman, M.S. in Ae.E., Chief of Operations Div., Cooperative Wind Tunnel; Lecturer in Aeronautics, GALCIT, California Institute of Technology.

Frearson, Harold, Technical Representative at Winter Experimental Establishment, R.C.A.F. (Edmonton), Rolls-Royce, Ltd.

Gross, Bernard, B.S., Dir. of Laboratories, Rohr Aircraft Corp.

Hayman, Richard L., General Mgr., Haskel Engineering & Supply Co.

Linnaluoto, Veikko Vihtori, Dr. of Sc. (Math. & Physics), Aerodynamicist (Aero-Elasticity), SAAB Aircraft Co.

Martinek, Johann, Dipl. Ing., Research Fellow, Harvard University (Navy Project), N.A.C.A.

Milan, George Charles, Layout Designer, Power Plant, The Glenn L. Martin Co.

Roos, Erik Gustav Tage, Civilingenjor, Aerodynamic Flight Research Engineer, SAAB Aircraft Co.; Officer & Flight Engineer, Royal Swedish Air Force Reserve.

Rother, Carl Joseph, Research Engineer "A," Mechanical Test Section, Engineering Test Lab., Consolidated Vultee Aircraft Corp.

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Salerno, Vito Lorenzo, D.Ae.E., Asst. Prof. of Applied Mechanics; Asst. Dir. of Aero. Structures Research, Polytechnic Institute of Brooklyn.

Smith, Lyman Dutton, Engineering Designer "A," Douglas Aircraft Co., Inc.

Sohn, Harry, M.A., Special Research Engineer, The Glenn L. Martin Co.

Warther, Mary A., A.B., Sr. Aerodynamicist, The Glenn L. Martin Co.

Williamson, Herbert Harris, B.S., Lt. Col. & Naval Aviator, U.S.M.C.; Commanding Officer, Marine Aviation Detachment, Naval Air Test Center (Patuxent River).

Zipkin, Morris A., M.S. in Ae.E., Engineering Specialist, Goodyear Aircraft Corp.

Transferred to MEMBER Grade

Baker, Joel Robert, Jr., B. of Ae.E., Staff Experimental Test Pilot & Project Pilot, Chance Vought Aircraft Div. (Dallas), United Aircraft Corp.

Bernhard, Maurice B., B.S. in M.E. & Ae.E., Flight Test Engineering Inspector, C.A.A. (Los Angeles).

Cohen, William S., B. of Ae.E., Aerodynamicist "B," Douglas Aircraft Co., Inc.

Conway, Robert Nelson, B. of Ae.E., Asst. Budget Officer, Langley Aero. Lab., N.A.C.A.

Fiul, Abraham, B.S., Aerodynamics Engineer, Northrop Aircraft, Inc.

Henry, Beverly Z., Jr., B. of Ae.E., Aero. Research Scientist P-2, N.A.C.A. (Langley Field).

Meghreblian, Robert Vartan, B. of A.E., Sr. Engineering Analyst & Asst. Project Engineer, Jet Propulsion Lab., California Institute of Technology.

O'Neill, James Eugene, M.S. in Ae.E., Sr. Engineer in Charge of Supersonic Wind Tunnel, Aircraft Div., Packard Motor Car Co.

Rousseau, William Arnold, B.S. in Ae.E., Sr. Aerodynamicist, Curtiss-Wright Corp.

Sheridan, Hugo G., B.S. in M.E. (Aero.), Aerodynamics Engineer, The Glenn L. Martin Co.

Weiss, Gilbert, B.Ae.E., Head, Weight Control Branch, Evaluation Div., Bureau of Aeronautics, Navy Dept.

Elected to Associate Member Grade

Brown, Leon D., Jr., Flight Test Conductor, Consolidated Vultee Aircraft Corp.

Fahim, Yousef Lotfy, B.S. in Ae.E. & M.E., Asst. Aero. Inspector, Civil Aviation Dept., Ministry of Public Defence (Cairo).

Grosser, Joseph F., President, Quaker City School of Aeronautics.

Huxley, W. P., B.S., Sales Mgr., Hamilton Standard Propellers; Asst. Secretary, United Aircraft Corp.

Majmudar, S. N., Chief Engineer, Civil Aviation Training Centre (India), Govt. of India.

Transferred to Associate Member Grade

Boschen, William O., B.S., Regional Aviation Sales Representative, Minneapolis-Honeywell Regulator Co.

White, John Henry, B.S., General Mgr., United Aircraft Supply Corp.

Elected to Technical Member Grade

Berger, Ernest John, First Lt., Naval Aviator, U.S.M.C.; Student, Test Pilot Training School, Naval Air Test Center (Patuxent River).

del Solar, M. Jorge Gonzalez, Ae.E., First Lt., Engineer, Argentine Aero. Purchasing Commission in U.S.A. for Instituto Aerotechnico (Argentina).

Fields, Raymond H., B.S.M.E. (Aero.), Engineering Asst., Mfg. Engineering Lab., Westinghouse Electric Corp.

Levin, Stuart Mayer, B.Ae.E., Structural Engineer "B," Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Loesch, Franklin Christian, S.M., Professor-Asst. of Aerodynamics, Institute of Technical Aeronautics (Brazil).

Nickel, Hal S., Jr., B.S., Aero. Project Engineer, David Taylor Model Basin (Maryland).

Nuttall, Leonard John, B.S.M.E., Technical Engineer, General Electric Co.

Rapp, Philip Crowe, B.A., Dynamic Analyst, Bell Aircraft Corp.

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Rockett John Alexander, B.S., Aero. Research Scientist, N.A.C.A. (Langley Field).

Sohn, David, A.M., Aero. Research Scientist II, N.A.C.A. (Cleveland).

Tunison, James B., Flight Test Engineer, Republic Aviation Corp.

Transferred to Technical Member Grade

Adkisson, Robert Eugene, "B" Draftsman, Douglas Aircraft Co., Inc., (El Segundo).

Allison, Martin S., Designer, Northrop Aircraft, Inc.

Andrews, Harold, B.M.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Badewitz, Charles J., B.S. Ae.E., Jr. Research Engineer, Research Foundation, Washington University.

Blau, William.

Bowton, James Russell, B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Brodsky, Robert F., M.Ae.E., Instructor in Mechanical Engineering, New York University.

Burkholder, James Raymond, A.A. in Ae. E., Flight Test Analyst, Ryan Aero. Co.

Cornford, Marvin Gene, Engineering Draftsman "B," Northrop Aircraft, Inc.

Criswell, Fay V., Draftsman "B," Northrop Aircraft, Inc.

Cummings, Robert Lee, B.S., Jr. Engineer, Lewis Flight Propulsion Lab., N.A.C.A. (Cleveland).

Des Jardins, Paul Russell, B.S. in Ae.E., Lab. Asst., Aircraft Ignition Development Section, General Electric Co.

Dodson, Gerald Edwin, Designer, Northrop Aircraft, Inc.

Drozdziel, Marion John, B.S. in M.E., Stress Analyst, Curtiss-Wright Corp. (Columbus).

Dumond, Ned E., Engineering Draftsman, Northrop Aircraft, Inc.

Duvivier, Jean F., Bacc. de Mathematiques.

Eidson, Theodore Harry, B.S. in Ae.E., Graduate Student, Iowa State College.

Eslinger, Norman F., B.S., M.E. (Aero.), Stress Analyst, McDonnell Aircraft Corp.

Farris, Edsel S., B.S. in Ae.E., Jr. Engineer "B," Propulsion Development Section, Boeing Airplane Co. (Seattle).

Frank, Nathan Joseph.

Grubin, Carl M., B.A.E., Research Asst. & Student, Polytechnic Institute of Brooklyn.

Hateley, James Charles, B.E., Aero. Engineer, Flight Test, Douglas Aircraft Co., Inc. (Santa Monica).

Hutchison, Charles M., Jr., M.S. in Ae.E.

Joppa, Robert Glenn, B.S. in Ae.E., Instructor & Research Assoc., Aero Lab., University of Washington.

Kavanau, Lawrence L., B.S.E. (Aero.), Research & Lab. Asst., Aero. Dept., University of Michigan.

Kolaga, Steward R.

Krebes, Joseph I., B.S. Ae.E.

Lane, Dean S., Ae.E., Research & Development Engineer, Goodyear Aircraft Corp.

Lehmann, E. C., B.S. in Ae.E., Lt., U.S.A.F.; Project Engineer, Air Materiel Command, Wright-Patterson Air Force Base.

Lerner, Eugene, B.Ae.E., Jr. Aerodynamics Engineer, Chase Aircraft Co., Inc.

Linardos, Nickolas John, Engineering Draftsman, Northrop Aircraft, Inc.

Lucas, Robert George, Engineering Draftsman "B," North American Aviation, Inc.

Luttrell, Howard M., A.A. in Ae.E., Engineering Draftsman "A," Consolidated Vultee Aircraft Corp.

Mango, Patrick James, A.A. in Ae.E.

McCarter, William B., B.A.Sc., Instructor in Aircraft Design, University of Toronto.

McClure, Forrest E., Engineering Draftsman, Northrop Aircraft, Inc.

Nemitz, Omer Eugene, Mathematician, Aerodynamics Dept., Douglas Aircraft Co., Inc. (Santa Monica).

Ohman, Allan B., Engineering Draftsman, North American Aviation, Inc.

Ohlsson, Oscar O., Jr., B.S. in Ae.E., Engineer, Structural Test Group, Boeing Airplane Co. (Seattle).

Orkin, Stanley S., B.A.E., Test Engineer, The Glenn L. Martin Co.

Paulnock, Russell S., B.S., Aero. Research Scientist, N.A.C.A. (Langley Field).

Peterson, Paul W., M.S. in Ae.E., Research Engineer, Well Surveys, Inc.

Polischuk, Myroslav S., B. of A.E., Jr. Design Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Portanova, Michael Anthony, B.Ae.E., Jr. Engineer, Propeller Div., Rocket Dept., Curtiss-Wright Corp.

Powers, Lawrence William, B.A.E., Test Engineer, General Electric Co.

Prout, Richard E., Engineer Draftsman "B," Northrop Aircraft, Inc.

Rudd, Gordon William, B.S. in Ae.E. & B.S. in Naval Science & Tactics, Project Engineer, Aerodynamics Div., David Taylor Model Basin (Washington, D.C.).

Schier, Robert F., B.S.M.E., Mechanical Engineer, Engineering Development Dept., Babcock & Wilcox Tube Co.

Sheckler, Ronald L., Engineering Draftsman "B," North American Aviation, Inc.

Smith, Philip L., B.S. in Ae.E., Aero. Engineer, Loads Div., N.A.C.A. (Langley Field).

Solarz, Sanford, B. of Ae.E., Draftsman, Chase Aircraft Co., Inc.

Stillwell, Wendell H., Weight Analyst, Northrop Aircraft, Inc.

Stockemer, Francis J., Flight Test Analyst, Lockheed Aircraft Corp.

Wong, Robert C., B.S.Ae.E., Aero. Engineer, Design, Douglas Aircraft Co., Inc. (Santa Monica).

Yaeger, David J., B.S. in Ae.E., Aero. Engineer, Structures Research, N.A.C.A. (Langley Field).

What Aeronautical Scientists Are Doing About the Weather

(*Continued from page 26*)

nobody knows what the eventual possibilities may be. In meteorology it is usually inaccurate to say that it is *impossible* to produce a weather condition artificially. Most weather conditions are the result of relatively simple elementary physical processes, and it is the combination of these elements on a vast scale in the free atmosphere that makes them complex and usually out of reach of artificial controls in everyday practice. It is therefore better to say that this or that method of weather "control" is practicable or impracticable rather than possible or impossible. An estimate of the factors, the size and forces involved in storms and the cost and consequences of large-scale weather control, leads to the belief that this will not be a general solution to the weather problems of aviation. Artificial control of certain local conditions of weather under special circumstances, such as fog dispersal at main airport terminals, will no doubt be practicable and worth-while, but the applications will certainly have practical limitations.

A brief view of certain weather research plans and prospects was given, with reference to the "57" thousand varieties of "three-dimensional weather."

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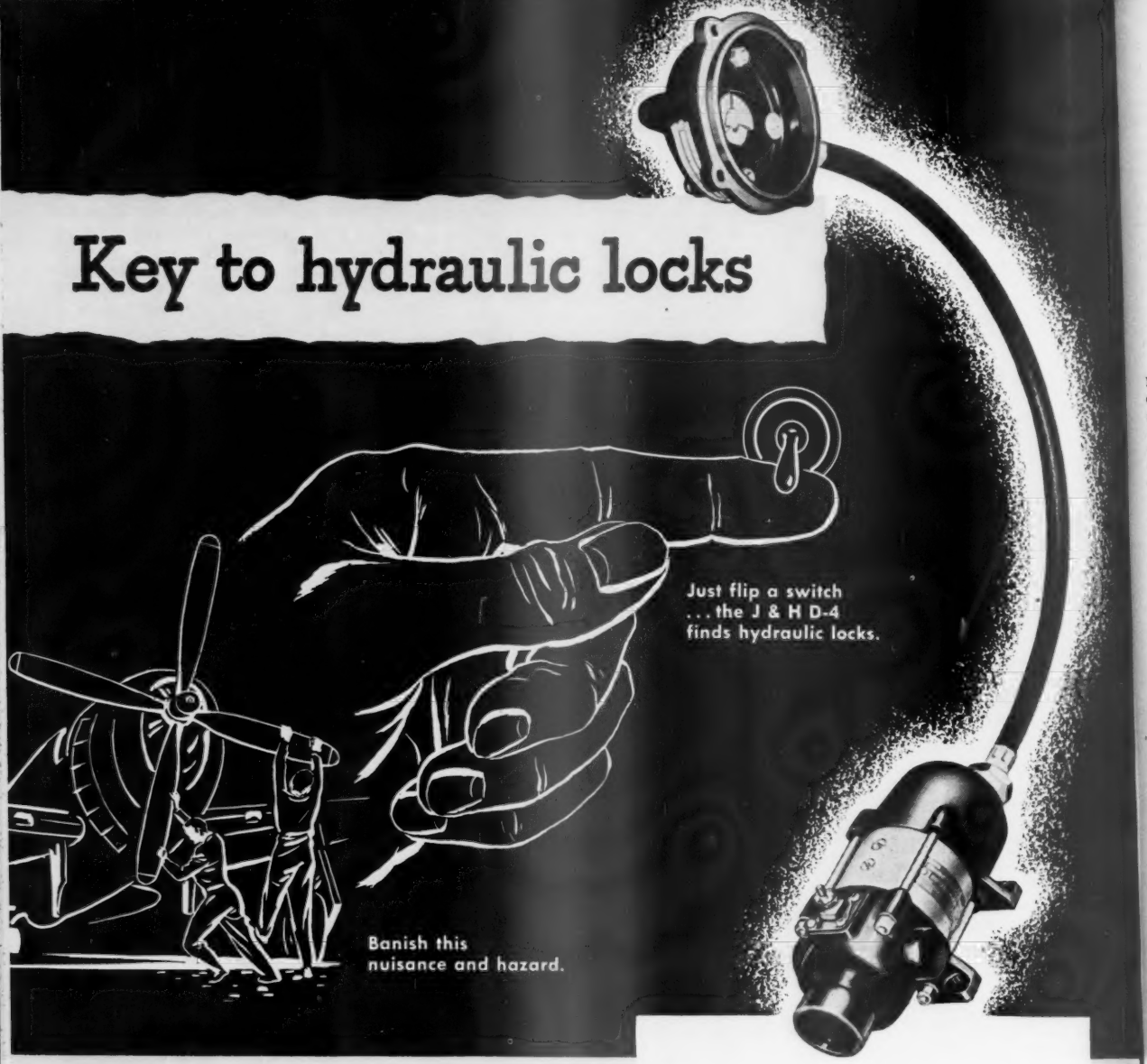

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Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute

WANTED

Electrical (Electronics) Engineers—Project Engineers, Designers, recent graduates. **Mechanical and Electromechanical Designers**—Minimum, 3 years' experience. **Layout Draftsmen (Electrical)**—Minimum, 3 years' experience design and layout electronic chassis. **Layout Draftsmen (Mechanical)**—Minimum, 3 years' experience design and layout small mechanisms, automatic machinery, etc. **Aerodynamicist (Aeronautical Engineer)**—Recent graduate or experienced. Mechanical engineering ability helpful. **Electrical (Electronics) Production and Manufacturing Engineers**—For supervisory manufacturing and production positions. Actual electronic production supervision experience essential. **Field Service Men, Electronic-Electromechanical**—Aviation background desirable. Recent graduates or experienced men. Will be trained at plant for field work. Single men preferred. Liberal expense and travel allowances. **Writers, Artists, Parts Catalog Compilers**—Technical publications. Experience essential, preferably on Government manuals covering electronic devices. **Inspectors, Electrical and Electronic**—Qualified in establishing electronic inspection procedures. Experience essential. These men needed immediately for interesting and permanent positions on an experimental, development, and production program of complex electronic and electromechanical equipment. Work covers computers, servos, amplifiers, instrumentation, small mechanisms in aircraft simulation for complex training equipment. Applicants should have college degree, equivalent experience, or both. Interviews will be arranged. Write Personnel Manager, Link Aviation, Binghamton, N.Y.; specify particular opening, qualifications, and salary expected.

Instrumentation Engineers—The Flight Test Division of the Naval Air Test Center, Patuxent River, Md., has the following vacancies: Electrical Engineer, P-4, $5,232; Mechanical Engineer P-4, $5,232; Mechanical Engineer P-3, $4,479.60; Electrical Engineer P-2, $3,727.20; Engineering Aide, Electrical SP-8, $3,727.20; Engineering Aide, Mechanical SP-8, $3,727.20. Assignments include strain-gage instrumentation, special flight installations, instrument developments, evaluations, and studies. Fill out Civil Service Application Form 57, obtainable at local post offices, and forward to: Industrial Relations Division, Naval Air Station, Patuxent River, Md.

Aeronautical Engineer—The Naval Air Test Center has an opening for an aeronautical engineer, power-plant specialist, to present courses of instruction on a college level in power-plant operation and installation and to do development work in the field of flight testing. Any applicant for this position should have at least a Bachelor's Degree in aeronautical engineering plus several years of teaching and/or industrial experience. Depending on the qualifications of the applicant, the position is either a civil service P-4 or P-5 paying from $5,232 to $6,235 per annum. Adequate low-cost Government housing for the man selected and his family is available immediately. All letters should be accompanied by completed copy of civil-service application form 57 obtainable from your local post office. Letters of application for this position should be addressed to: Director, Test Pilot Training Division, Naval Air Test Center, Patuxent River, Md.

Rocket Designer—Position available for graduate engineer experienced in development of rocket motor and missile launching equipment. Salary open. Personnel Office, Hughes Aircraft Company, Florence Ave. at Teale St., Culver City, Calif.

Industrial Engineer—U.S. Civil Service Grade P-5, starting salary $6,235.20 per year. *Basic Requirements:* A graduate engineer, experienced in methods, cost control, and budgeting work. Will be expected to initiate studies and work with cognizant department heads toward more efficient use of research and development and support funds through improvement of organization and improved use of man power. Will initiate and supervise maintenance of work measurement and progress record programs. Applications for the above position should be filed with the Executive Secretary, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Thermodynamicist; Flutter Engineer—M.S. in engineering, with some training in aeronautics. Thorough mathematical background, working knowledge of compressible fluids, engineering thermodynamics and heat transfer, experience in gas-turbine work preferred. For analysis and development work on engines for advanced military aircraft. Also Flutter Engineer: A.E. graduate with several years' experience in flutter and vibration problems. Salaries commensurate with training and experience. Please include complete summary in reply to Engineering Personnel Office, North American Aviation, Inc., Los Angeles Airport, Los Angeles 45, Calif.

Aeronautical Engineers—Fairchild Aircraft Division, Hagerstown, Md., has vacancies in its Engineering Department at Hagerstown and also branch engineering office, Washington, D.C., for engineering draftsman, layout engineers, aerodynamicists, electrical engineers, structures, and research engineers (with Ph.D. in Math or Physics). For immediate details write Employment Manager, Fairchild Aircraft Division, Hagerstown, Md.

Engineers—Engineering draftsmen, engineering designers, and aerodynamicists for research and development work on B-36, world's largest bomber, and other advanced Air Force designs. Positions are also available for tooling personnel. Write for application blank to Engineering Personnel Office, Consolidated Vultee Aircraft Corporation, Fort Worth, Tex.

Research Engineer—For analysis of internal flow conditions and stress design of motor cases for jet propulsion devices. Five to 15 years of technical experience preferred. Jet propulsion experience helpful but not necessary. Problems involve knowledge of some thermodynamics, fluid flow, and stress analysis. This represents an opportunity with a young and rapidly growing activity. Salary offered will depend on experience. Write to: Thiokol Corporation, Elkton Division, Box 244, Elkton, Md.

Organic, Inorganic, and Physical Chemists—Immediate openings. Ph.D.'s preferred. Men with firm background in the following; formulation development, chemical kinetics, organic synthesis, mechanisms of reactions, inorganic synthesis, mathematics, thermochemical measurements, physical constant measurements. Applicants must furnish information concerning experience, personal data, recent photo, required salary and college transcripts. All correspondence will be kept confidential. Apply: Aerojet Engineering Corporation, P.O. Box 296, Los Angeles County, Azusa, Calif.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Aeronautical, Electronic, and Electrical Engineers—The Aeronautical Structures Laboratory of the Naval Air Experimental Station is seeking engineers in several fields for employment in Philadelphia, Pa. Fifteen vacancies exist for aeronautical, electrical, and electronic engineers and engineering aides. Applications are desired from persons who have had training and experience in the fields of engineering described below. Applications for the positions should be made on Standard Form 57, available at any first- or second-class post office, and should be mailed to Industrial Relations Officer, Naval Air Material Center, U.S. Naval Base Station, Philadelphia 12, Pa. **Aeronautical Engineers (Structures)**—Structural development and flight tests. Analysis of loads in aircraft components imposed by high air speeds and accelerations; static and dynamic testing of aircraft structural features; development of test equipment, methods, and procedures; analysis of data; and preparation of reports. Six P-1 grades at $2,974.80 per year and three P-2 grades at $3,727.20 per year are open. **Electrical and Electronic Engineers**—To develop, evaluate, and operate special laboratory and flight-test equipment. Includes direct and remote recording (Telemetering) equipment, the pickup instruments, such as strain gages, accelerometers, air-speed indicators, altimeters, etc. One P-1 grade at $2,974.80 per year, two P-2 grades at $3,727.20 per year, and two P-3 grades at $4,479.60 per year are open. **Engineering Aides**—Provide assistance to professional engineers performing the duties described above. Prepare sketches for laboratory test preparations. Provide liaison between laboratory and engineering offices. Record data such as strains and deflections. Make tabular calculations and prepare graphs as direct. One SP-5 position is open; salary $2,724 per year.

Electrical Engineer—To coordinate and develop electrical equipment for rocket motor projects such as ignition systems, starting, instrumentation, test equipment, interlock and limit switches; should be familiar with aircraft standards. Address: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Liaison Engineer—Basically a good designer familiar with rocket motor development to coordinate development work of staff engineers with customer and contract requirements. Address: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Technical Writer—To prepare service, operation, overhaul, and similar data on rocket motors and their associated equipment. Address: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

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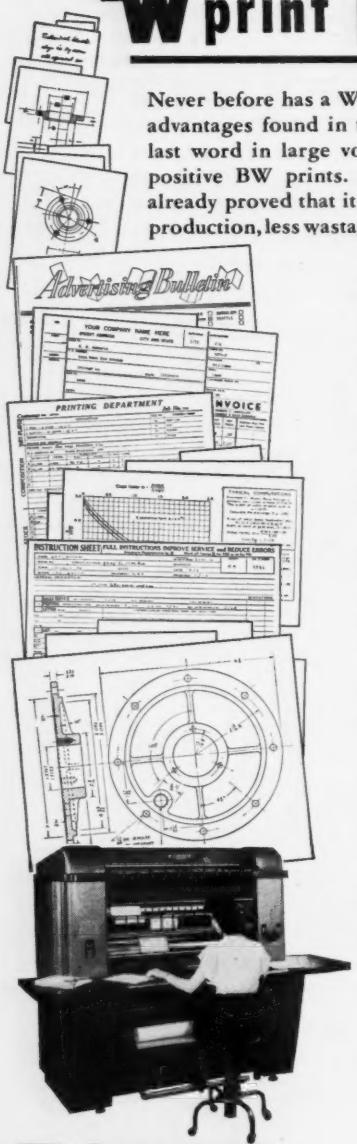

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Helicopter Engineer—Experience in helicopter aerodynamics and stress analysis required. Apply in writing with a résumé of experience and education to American Helicopter Company, 900 N. La Brea Ave., Inglewood, Calif.

AVAILABLE

942. Gas Dynamicist—B.S. and M.S. in M.E. from M.I.T. Age 30. Advanced fluid mechanics, heat transfer, and thermodynamics. Experience in analysis, research and development of jet propulsion power plant. Desires permanent and responsible position, possibly with opportunity to continue work toward D.Sc. Available by Summer, 1949.

941. Aerodynamic and Flight Test Engineer—B.Ae.E. from New York University. Now taking Masters Degree in M.E. at University of Pennsylvania. Some experience at flight-test data evaluation, flight-test instrumentation, and aerodynamic performance analysis. Desires position as Junior Engineer at location that will permit continuation of graduate studies. Single; age 20.

940. Aeronautical Engineer—B. Aero. E., 1938. Ten years' experience in aircraft production, material, new design, and sales-engineering. Past 3 years domestic and foreign sales contact work; has supervisory and public relations experience.

939. Aeronautical Instructor—Administrator—Unusual background: Degree in physics, also major in chemistry, Johns Hopkins. Three years teaching and administrative experience, U.S.A.F. technical schools in engine test, carburetion specialization, flight-line maintenance. Instructor in aviation mechanics for the Brazilian Air Force and assistant chief of the Engineering Projects Division for the Brazilian Ministry of Aeronautics, serving as administrative chief of 400 Brazilian technicians. Considerable experience in personnel administration in the U.S.A.F. as civilian chief instructor and also as engineer in Brazil. Has just returned from a 3-year stay in South America. This last year spent only in traveling and observing all South American countries. Can speak and write fluent Portuguese and Spanish. Any location.

938. Personnel Manager—B.S. Ae.E. and M.S. in Industrial Psychology, both Purdue. Two years engineering department international air line. Present position—personnel manager, West Coast firm. Location open.

937. Aeronautical Engineer—Swedish aircraft engineer who visited U.S.A. during 8 months in 1947 wants to come back. Head of Air Force project group, experienced in transonic and research aerodynamics, stress analysis, and project engineering. Eight years' experience in teaching. Advanced degree in aeronautical engineering 1945 at the Royal Institute of Technology in Stockholm (Civilingenjor). Age 31; married.

936. Management or Executive Engineer—Graduate Engineer, age 37, with over 13 years of aircraft experience on Navy airplanes with one company. Background involves: approximately 7 years' experience in stress, analysis, airplane structural design and testing including responsible charge of the stress analysis section; over 5 years in project engineering work in charge of the design and development of an experimental and major production Navy airplane, including broad engineering administrative and supervisory experience in responsible charge of all design development work and customer contact on several airplane designs; over a year's experience in a

manufacturing supervisory capacity. Desires a responsible position with an aircraft manufacturer or allied industry seeking management or executive talent.

934. Instrumentation and Liaison Engineer—Twelve years' all-around experience on experimental reciprocating type aircraft. Three and one-half years specializing on development, manufacturing, and installation of special instrumentation for experimental jet aircraft. Some experience on instrumentation on guided missiles. Desires position on West Coast or in South in related work. Single, age 29; free to travel; would consider service engineering position.

932. Engineering, Management, or Administration—B.S. in M.E. and Master Degree in A.E. Over 20 years' experience in aircraft and missile design, manufacture, and flight test involving C.A.A., Army, and Navy. Directly responsible for design of at least eight airplanes. Detail experience includes 13 years of stress analysis, project design, testing, flight test. The last 7 years of this period supervised all of the above in capacity of chief engineer. Factory manager responsible for planning, tooling, and production for 3 years, then assistant general manager. Manager of divisions of two large corporations for the last 5 years. Desires responsible position as engineering or management executive.

931. Engineer-Lawyer—B.S. in M.E. (Aeronautical Option) in 1942. Four years' experience; 1 year in stability research in a N.A.C.A. wind tunnel; 3 years in the Navy as maintenance of aircraft and in BuAer as assistant on a design desk. Will graduate from Stanford Law School, May, 1949. Desires position in which both backgrounds will be useful. Prefers West Coast.

929. Aeronautical Engineer—Fourteen years' experience, last 10½ in aircraft design. B.S. in M.E. 1934 from Guggenheim School of Aeronautics of New York University. Has held position as designer, project engineer, chief aerodynamicist, and acting chief engineer and has been active in design of metal and wood aircraft for Navy and civil use, helicopters, and propellers. Desires responsible position requiring imagination and activity. East Coast preferred.

928. Aeronautical Operations Engineer—Just completed installation of passenger and cargo service in South America. Efficient, capable operations engineer with an outstanding record. Winterization expert and specialist on sub-zero operations. Former superintendent U.S. Air Mail. Capable of supervising flight-test operations or assuming position as assistant to busy executive. Former general manager of air line.

927. Management, Engineering Administration—Age 46, born New York; 2 years Rensselaer Polytechnic Institute; 2 years University of Virginia; special courses civilian and service schools. Approximately 9 years' aircraft construction with four aircraft concerns; 8 years' additional as naval officer assigned as the Bureau of Aeronautics Representative at three major aircraft plants. Associate Fellow I.A.S., Member A.S.C.E., Theta Tau, Rensselaer Society of Engineers, Phi Delta Theta.

926. Manufacturers Representative—Aeronautical operations engineer, highly capable sales and technical representative. Twenty-five years in aviation field. Well and favorably known to most aircraft manufacturing and aircraft operating executives. Has outstanding record in aeronautics. Recently operating in South America. Prefers Pacific Coast assignment, but will consider Eastern connection.

925. Research Associate Professor—Six years' university training as aeronautical engineer. Five years in design and production of Navy aircraft; 3 years' teaching combined with experimental research. Desires permanent position as research, supervisor and graduate teaching opportunity. Special field—supersonic and transonic aerodynamics. Family housing essential.

924. Engineer—Graduate (Majors in Physics and Mathematics) of University of California. One year's graduate work in Physics. Five years' experience as a stress analyst and dynamicist in aeronautical engineering.

923. Writer, Technical or Advertising—Will help sell product, proposal, or idea by writing ads, booklets, promotional letters, publicity articles, or reports; will edit, ghost-write, or collaborate on technical articles. Writes technical descriptions that are easy to understand by non-technical men. Experienced engineer, able to see things from prospect's point of view, analyze products, pick out points that appeal, and present them in manner that invites action. Full or part time.

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920. Aeronautical Engineer—Wind-Tunnel Assistantship and M. S. in Aeronautics, Cal Tech. Nine years' experience all phases of aerodynamics including performance, stability, flight-test, preliminary design. Specializing in wind-tunnel testing including model design, preparation of programs, testing and tunnel operation, analysis of results, and company representation for aircraft and missile projects.

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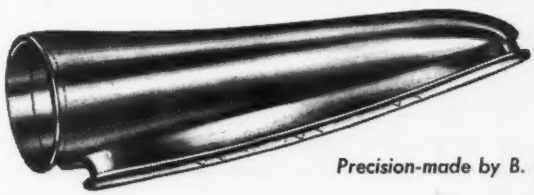

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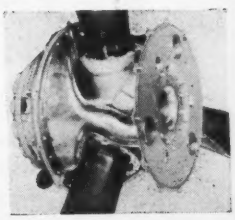

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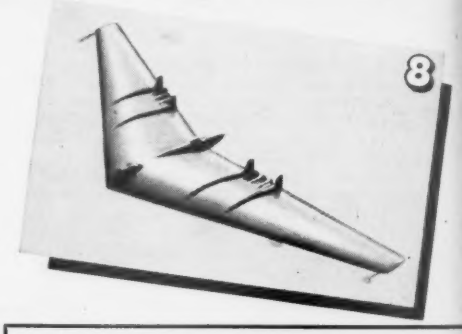

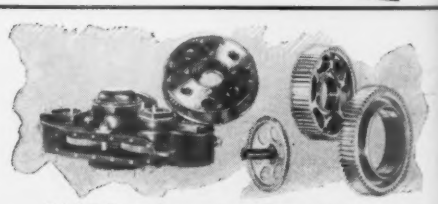

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